Reviews and Abstracts: Vol. 1, No. 6

ANALOG COMPUTER TECHNIQUES

282:

HUNT, DARWIN P. **Tracking performance as a function of feedback specificity.** Wright Air Development Center Technical Report 58-584, March 1949.

This paper describes experiments designed to advance knowledge concerning human performance and the specificity (or resolution) of feedback information. It essentially demonstrates the fact that, as resolution improves, so does performance.

The apparatus used involves a target course generator, an error transformer, a cathode ray tube display, a lever control, and an analog computer. Four degrees of resolution and two levels of task difficulty were studied in the performance of a one-dimensional compensatory tracking task using an acceleration control. Eight sets of eight male university students were paid to perform each of the eight combinations of tasks. Tracking error and control motion scores were recorded and subjected to an analysis of variance.

Papers on earlier work by Ammons, Bilodeau, Schoeffler, Rund, and others are summarized. These presented hypotheses not necessarily substantiated by performance tests. It is now found that (i) as the operator becomes more proficient the superiority of the greater number of categories is reduced (rather than increased), and (ii) there does not appear to be an optimum degree of specificity of feedback information. Further, the present study suggests that (iii) the effect of the number of categories of information on control motion depends on the difficulty of the task, and (iv) the control motion scores decrease more as a result of practice on the "easy" task than they do on the more "difficult" one.

The following criticisms are offered: (i) The signal in the "difficult" task contained extremely low frequency components; additional work combining 0.6, 1.2 and 3 cycles-per-second sine waves might profitably be carried out. (ii) The duration of the individual tasks (90 sec.) seems rather low unless starting conditions were always the same. (iii) A 5-inch C.R.T. screen seems rather small for this type of experiment. *Beatrice H. Worsley*, Toronto, Ont., Canada

283:

SEYFERTH, VON H. **Uber die Behandlung Partieller Differential-Gleichungen auf dem elektronischen Analogrechner** (On the solution of partial differential equations by means of an electronic analog computer). *Elektronische Rechenanlagen* **2,** 2 (May 1960), 85–92.

This paper describes methods for the solution of the heat equation, wave equation, and the fourth order equation of rotating shafts through the use of electronic analog computers. In each case, the spatial coordinates are replaced by discrete points, the spatial derivatives by finite differences of a natural sort, and the equations are converted to coupled systems of ordinary differential equations. Considerable care is devoted to obtaining suitable difference formulae at the spatial boundaries. Schematics of particular computer set-ups are shown, together with a comparison between the electronic analog computer solution and the exact solution for test problems which can be solved analytically. (The reviewer notes a growing instability in the exhibited solutions to the wave equation and conjectures that some mathematical problem is involved in choosing adequate difference quotient approximations for this type of problem.) The exposition is clear.

Arthur Wouk, Waltham, Mass.

284:

BRIK, V. A.; AND GINZBURG, S. A. **An analog computer realizing conformal mapping for an n-th order polynomial.** *Automation and Remote Control* **19,** 7 (Apr. 1959), 664–672. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 7 (July 1958), 674–683. by Instrument Society of America, Pittsburgh, Pa.)

An analog computer is described that makes it possible to analyze nth order polynomials ($n = 1, \cdots, 10$) with real and complex coefficients. The main purpose of the machine is to determine the roots of characteristic equations and plot Mikhailov loci. *(From Authors' Summary)*

Courtesy *Appl. Mech. Rev.* **13,** 8 (August 1960)

285:

IVLICHEV, IU. I.; AND NADZHAFOV, E. M. **A universal pneumatic multiplier-divider and a square-root extractor.** *Automation and Remote Control* **19,** 11 (June 1959), 977–988. (Translation of *Avtomatika i Telemekhanika, USSR* **19,** 11 (Nov. 1958), 997–1009. by Instrument Society of America, Pittsburgh, Pa.)

Pneumatic analog computer, where inputs and outputs are pressures $P_1P_2P_3P_4$. Balanced bridge consisting of nozzle amplifiers insures relationship $P_1P_1 = P_3P_4$. It operates multiplication, division, square root, squaring. Three-place accuracy is claimed, with examples of actual performances.

Reviewer believes this is a new and useful device, although dynamic response is just sketched.

J. M. Loeb, France

Courtesy *Appl. Mech. Rev.* **13,** 8 (August 1960)

APPLICATIONS TO LINEAR AND DYNAMIC PROGRAMMING

286:

MILLS, HARLAN. **Equilibrium points in finite games.** *J. Soc. Indust. Appl. Math.* **8,** 2 (June 1960), 397–402.

The author gives several algebraic characterizations for Nash-equilibrium points of finite zero- or nonzero-sum n-person games. For two-person games, one characterization is a quadratic programming problem (linear constraints). A second characterization is a system of linear inequalities plus one quadratic equation. In zero-sum games the quadratic terms vanish, and in this case one gets well-known linear systems for the optimal strategies. A third characterization is a linear program where certain variables are restricted to the values zero and one. The given characterizations allow the determination of equilibrium points by existing computational techniques. In general, n-person games one gets a system of nonlinear inequalities or alternatively a nonlinear program. The equations and inequalities can be written down immediately if the game is given in normalized form.

H. Bottenbruch, Oak Ridge, Tenn.

287:

BOYD, K. T. **Simultaneous equations and linear programming.** *Comput. J.* **3,** 1 (April 1960), 45–46.

Suppose a machine program is available to solve a linear programming problem. Specifically, the program finds the values of x defined by the equations:

(i) $Lx = L_0$

(ii) $\sum c_j x_j = \text{Max}$

(iii) $x_j \geqq 0$

Following an earlier proposal of M. L. Deutsch in a letter (*Comm. ACM*, **2,** 3 (1959), p. 1), the author finds a general set of inputs which will enable the program to invert a matrix A and to solve $Ax = K$. The leading difficulties are finding a suitable cost criterion—equation (ii)—and avoiding negative elements in K and $A^{-1}K$. The author proves that the following inputs meet the conditions:

$$L = [A\ K\ I]$$

$$C = [0\ -1\ -P']$$

$$L_0 = AP$$

where P is a column vector of units and enough rows of A are multiplied by -1 to make all elements of AP positive. The inversion of a matrix of order m, therefore, is converted to a linear programming problem of order $2m + 1$ by m. A particular solution is obtained at the same time.

E. D. Schell, Mountain Lakes, N. J.

288:

● FERGUSON, ROBERT O.; AND SARGENT, LAUREN F. **Linear programming.** McGraw-Hill Book Co., New York, 1958, xiv + 342 pp., 24 cm. $10.00.

(Rev. 67, *Math Comput.* **14,** 71 (July 1960), 299)

ARTIFICIAL INTELLIGENCE

289:

BUSHOR, WILLIAM E. **The Perceptron—an experiment in learning.** *Electronics* **33** (July 22, 1960), 56–59.

An experimental machine has now been developed to test some concepts of the operation of a network of signal generating units. The task to which this machine has been put has been pattern recognition, such as the discrimination of some letters of the alphabet. The units of the experimental machine are the sensory, the association, response, and zeroing units. In the case reported here the sensory units were photoresistive matrices. Learning curves are shown in the article for various types of training (forced and corrective) and for learning under various conditions (noiseless and noisy stimuli, perfect and imperfect operator performance, and changes in configuration of stimuli or machine).

Ned Chapin, Menlo Park, Calif.

AUTOMATIC PROGRAMMING

290:

Automatic Programming Information. Automatic Programming Information Centre, The Technical College, Brighton, England.

This is a mimeographed bulletin containing reports of work in automatic programming, published every two months. The September issue has seventeen legal-size pages and covers such items as "Comment on Genie (the Rice Institute Computer)", "ALGOL" including abstracts of papers on that language, "Towards a Common Business Language", and "Common Symbolic Language" including abstracts of papers given at the International Conference on Information Processing. Most of the material is unsigned.

(*The Editors*)

291:

SESTIER, A. **Remarques sur la structure de certains langages artificiels utilisés dans calculateurs numeriques automatiques** (Remarks about the structure of certain artificial language used in automatic digital computers). *Chiffres* **2,** 1 (March 1959), 1–20. (French)

The paper is concerned with translation. It is claimed that any translation process is best done in more than one stage. First, there is translation from original to some intermediate language. Secondly, translation from this intermediate language to the target language. The intermediate language must be readily manipulable, yet at the same time have some of the richness of the various possible source languages. The proposed solution to the problem of simplicity and richness is said to be in the construction of suitable tables of definitions and relationships. An example is given in which the original language is an algebraic statement and the target language is machine-like. The

intermediate language is a single table, the dictionary. The representations of the algebraic statement in this language are tabular. It is asserted that this approach will be of value in such fields as organic chemistry, circuit design, and other formal systems.

M. de V. Roberts, Yorktown Heights, N. Y.

292:

POYEN, J. **AP 3-autoprogrammation pour Gamma 60** (AP 3-autoprogram for the GAMMA 60). *Chiffres* **2,** 2 (June 1959), 123–138. (French)

AP 3 is a synthetic language very similar to the language of mathematics and is designed for use in the computer GAMMA 60 (from the abstract). AP 3 is similar to languages such as FORTRAN in many respects but at the same time does have a number of points well worth noting. Certain new symbols are introduced including a lower case alphabet. Other significant features are the ability to do real and complex arithmetic in either single or double precision and an "execute" command which permits the repetition of a calculation represented by a group or groups of statements. It appears that AP 3's major distinguishing contributions to automatic programming are its ability to do more complicated arithmetic, the introduction of new symbols, and a more extensive command structure.

D. L. Thomsen, Jr., White Plains, N. Y.

293:

SENKO, M. E. **A control system for logical block diagnosis with data loading.** *Comm. ACM* **3,** 4 (April 1960), 236–240.

The PK-MAD diagnostic monitor system embodies further attempts at developing economical debugging facilities. The system described in this paper is essentially an automated approach to the familiar procedure of writing logical blocks of a program as closed subroutines and then writing driver programs to create the necessary environment for testing each subroutine. In the PK-MAD system, the logical blocks of program are defined by the programmer in a "diagnostic program". This "diagnostic program" is written in a language and format very much like that of any symbolic program. Its pseudo and macro operations are interpreted by the system. In addition to defining the logical bounds of each program block, the diagnostic program provides data for initialization of arithmetic unit and storage registers, print specifications for snapshots, and maximum execution time of a block for each test condition indicated. Using this information, the system provides the operating environment for each section of program being tested. Also entry and exit paths between the subject program and the system are established. At the conclusion of testing for each block, any instructions that were displaced to make room for these paths are restored.

D. N. Clark, Canoga Park, Calif.

BUSINESS DATA PROCESSING

294:

JACOBSEN, VON H. **Speichergröße für elektronische Rechenanlagen im Bankbetrieb** (Storage capacity of electronic computers in banking). *Elektronische Rechenanlagen* **2,** 2 (May 1960), 66–74. (German)

Obviously, the nature and capacity of storage is dependent upon the specific applications. The author uses as a base the information content of traditional applications handled by conventional procedures. He extrapolates to obtain estimates of character complement, field description, and clustering into items. He displays the field content and coding requirements for transaction varieties and files associated with each of several banking applications. There is some consideration of which fields are only translated in space and which are transformed by calculation.

The emphasis is on character counts for various item designs. Little or no consideration is given to file lengths, number of transactions in a given period of time, requirements for storage accessibility inherent in an application, the usual cost-volume-access time relationships, etc. Also, no consideration is given to the integration of file structure possible in a well-organized computer system. The article should prove useful to "product planners" and others attempting to discover and translate application requirements into specifications for hardware systems.

H. N. Laden, Cleveland, Ohio

295:

FISKE, JOHN W., JR. **Utilizing electronic equipment.** *Auditgram* **36,** 8 (August 1960), 18–23.

Mr. Fiske describes the program of clerical automation at Bankers' Trust Co., New York, from the introduction of punched cards in 1934 to the present use of a 650 tape system and plans for magnetic character recognition. The planning principle stressed is "development in depth". Line organization involvement and understanding is a byproduct of multiple, decentralized "tab shops" in the early days. The input/output functions are still decentralized; others integrated in the computer service center. The applications are personal trust work, deposit accounting for individual and corporate accounts, and own employee checking accounts. The major portion of the article is devoted to a brief history of the company's development effort in the electronic deposit accounting from feasibility studies through interim experimentation with posting machines and activity within ABA Committees up to present plans for use of magnetic ink checks and precoded deposit slips, and for the usual system design employing electronic equipment available upon the resolution of the basic input problems. An interesting aspect of the development work was that a punched card system for employee personal checking accounts was installed early to bypass the input problem present in general public accounts and serve for experimentation with proof of the major recordkeeping aspects of the system.

H. N. Laden, Cleveland, Ohio

296:

Gearing, H. W. **Problems in installing data processing equipment in business.** *Comput. Bull.* **4,** 1 (June 1960), 3–6.

The objective of this paper is to inform people familiar with scientific computer applications about the problems involved in business data processing. Although he suggests that the major difficulty is the coupling of human beings with computer devices, the author omits any specific reference to business system design from his otherwise quite appropriate listing of problems. A reader should expect interesting commentary on data processing, but the paper does not establish the exact nature or magnitude of the problems involved.

William A. Smith, Jr., Bethlehem, Pa.

297:

The consolidated functions approach. *Management and Business Automation* **4,** 3 (Sept. 1960).

The consolidated functions approach is the term used in insurance data processing to describe the method of servicing policy accounts by periodically examining a master file of all the policies, and carrying out all the operations on each policy in turn (as opposed to grouping the policies according to the operations required and processing them in batches). The implementation of the consolidated functions approach to the Minnesota Mutual Life Insurance Co. is described. Two hundred and twenty thousand policies are processed, in a monthly cycle in 140 hours per week on a Datatron 205 computer equipped with magnetic tapes, card input and output, and a Datafile. Included among the operations are premium billing, premium accounting, commission calculation, maintenance of loan status, dividend accounting, status updating, and the answering of information requests. A careful analysis of the operation indicates that savings of about $100,000 a year (based on a five-year amortization and ten-year use of the system) are to be expected. *C. C. Gotlieb*, Toronto, Ont., Canada

298:

Finelli, John J. **Development of EDP units.** *Comput. Bull.* **4,** 1 (June 1960), 10–17.

This article could better be entitled, "Metropolitan Life Insurance Company's Successful Use of Large Computers". The author relates his company's experience with computers since 1954, giving, in answer to questions from the floor, specific comparative cost figures of hand and punched-card processing versus machine computation. Presently using three Univacs operating 20 hours a day, six days a week, Metropolitan Life has been able to affect a 50% reduction in cost over the punched-card operations thereby displaced. Though this is a large figure, the author hopes to increase this saving by the use of more up-to-date equipment, but points out that one must be able to keep a large machine busy, the machines must be reliable, and proper advance investigations of the systems are necessary. The development of initial or new procedures, he further points out, is probably no more expensive for computers than similar changes for clerical and punched-card operations. However, in order to limit these costs he suggests the use of automatic coding devices such as compilers. Metropolitan Life is presently engaged in building a compiler. The article is general in nature, but may be of interest to those who are involved in processing a large amount of data. *Herschel Harrison*, Washington, D.C.

299:

Müller-Lutz, H. L. **Der Digitalrechner im Versicherungswesen** (Digital computers in the insurance industry). *Electronische Rechenanlagen* **2,** 1 (February 1960), 8–12. (German)

According to the article, developments in applying and installing digital computers in the United States precedes by five years similar events in Europe. Thus the writer draws heavily upon American experience in discussing the uses of computers in the insurance industry. Data on the number of installations are given through 1959 for the U. S. and for Europe, along with the 1960 "on order" position.

The factors which fostered the rapid introduction of computers into the insurance industry are cited as: (1) the conversion of mathematical work to computers, and (2) standardized production type work associated with the issue of policies. To these approaches, which are often used, he adds on which is infrequently used: (3) the organization of many subsidiary processes into a single closed operation. The last approach, for which Americans have coined the term *office automation*, he sees of greater importance for progress in Europe than in the United States. The large size of many American insurance companies have made it possible to show profits on a single massive subsidiary process; the smaller size of the European companies will often preclude this approach.

Insurance industry work which can be converted to computer processing is discussed under three headings: (1) one-time special jobs, (2) recurring special work, (3) systematic repetitive work. The first comprises such tasks as premium rate or auditing rate computations, conversions and statistical work; these, the author feels, seldom justify a large scale computer and are most economically performed at a service bureau. The second includes payroll, property administration, and mathematical work, such as the calculation of cash redemption values and statistical reports to government agencies; only in large companies do these merit the installation of a large-scale computer. Under the third, all tasks are grouped which are required to maintain contact with the customers; these include the printing of premium notices, maintenance of the customer file with its associated bookkeeping, the apportionment of earnings, and the calculation of commissions. More than 90% of all insurance companies use digital computers, at present, only for a single mass computation from this third group.

Diagrams showing the integrated operation of the All State Insurance Company on a Burrough's Datatron are

given. In another example, the reduction of manual handling is shown by a comparison of a digital computer run with the same operation on a conventional punched card system. Finally, a chart gives man hours for the initial work and the repetitive work associated with 1,000 property insurance policies using (1) handwork, (2) typewriters, (3) typewriters and desk calculators, (4) bookkeeping machines, (5) bookkeeping and addressograph machines, (6) punch card systems, (7) electronic calculators. The author regards cost considerations as the ultimate criterion for settling the question of conversion for the insurance industry. In closing, he quotes George Tattevin, President of the Committee for Action in Insurance Productivity (translated from the original French): "I am convinced that in a relatively short time those insurance companies using electronic computers will show such superiority over the others that the others will be obliged to convert or disappear."

E. D. Schell, Mountain Lakes, N.J.

300:

●POSTLEY, J. A. **Computers and people.** McGraw-Hill Book Co., New York, 1960, 10 + 246 pp. $6.00.

This book concentrates on the business applications of computers to data processing, though there are side remarks on other uses. It is a very intelligent discussion of the whole complex subject, and while this reviewer disagrees with the author at several points (. . . indeed almost nothing has been done to improve the basic set of orders . . .) it is a remarkably accurate book. The author is not afraid to face the topic of the future development of computers and the applications of them, and many of his opinions will probably come true. It is not possible to summarize such a book in a few paragraphs, so that all the reviewer can do is recommend it for reading both by those in the computer field, as well as those in business who are about to enter the field. It is well written and makes pleasant, thoughtful reading.

R. W. Hamming, Murray Hill, N.J.

301:

●GREGORY, R. H.; AND VAN HORN, R. L. **Automatic data-processing systems: principles and procedures.** Wadsworth Publishing Co., San Francisco, 1960, 705 pp. $11.65.

"In 1956 the Army Ordnance Corps initiated an automatic data-processing systems (ADPS) career program for education of top management, training in needed skills, and career development. One urgent requirement in this program was a comprehensive textbook; to fill that need, this ADPS textbook was developed and written under contract with the Massachusetts Institute of Technology. The book deals with business-data processing. It is introductory, requiring no previous knowledge of electronic computing systems. Computer programming and systems analysis are covered in detail. More important, a blending of theoretical and practical approaches to data processing explains why, as well as what, and how. Some new concepts in management information are developed, and management tools and techniques are included."

The book consists of seven parts. Part I, "Orientation," explains the concepts of data processing, processing data by machines, and gives an introduction to computer programming. Part II, "Automatic Equipment," describes the various units, input-output, arithmetic storage and control, and gives some general features of automatic data processing equipment, as well as some information on presently-available equipment. Part III, "Programming and Processing Procedures," covers additional programming techniques, such as subroutines and automatic programming, and discusses such business data processing procedures as file maintenance, sorting, etc. Part IV, "Principles of Processing Systems," discusses the difference between data and information, describes the objectives and the procedures for systems analysis and design, and covers systems economics. Part V, "Systems Design," goes into the organizational structures for data processing operations, and describes additional tools for systems analysis including flow charts, data sheets, etc. Part VI, "Equipment Acquisition and Utilization," describes the procedures involved in the feasibility study, the application study and equipment selection, installation, and review. Part VII, "System Re-examination and Prospective Developments," deals with the scientific decision processes in management and with prospective developments both in equipment and future data processing systems.

The book contains a number of desirable features. The order code used as a vehicle for describing programming covers only the initial part of the book. Anyone wishing to use another instruction code can omit a few chapters and use the rest of the book. Each chapter is followed by a summary and an annotated bibliography. The appendix contains the history of computation devices, questions and problems for each chapter, and a glossary of terminology. The authors have gathered together, in one volume, a vast amount of information dealing with the methodology of applying digital computing systems to business data processing problems. They present this information in a concise and well-organized fashion. The book is not one of the usual high-pressure volumes written to impress and awe rather than to inform management. While this book may be read with profit by management, its major value will be to systems analysts, programmers, and management personnel responsible for making data processing systems work in business firms. It is also, in the reviewer's opinion, the best currently available textbook for courses in business data processing. *D. Teichroew*, Stanford, Calif.

302:

DREYFACK, RAYMOND. **Giant brain—or giant moron?** *Office Management and American Business* **21** (May 1960), 25–26, 28–30, 32.

This is a simplified and superficial treatment of some of

the features of computers and the factors affecting their use in business applications.

Ned Chapin, Menlo Park, Calif.

COMPUTERS AND EDUCATION

303:

• Ulam, S. M. **A collection of mathematical problems.** Interscience Tracts in Pure and Applied Mathematics, Number 8, Interscience, New York, 1960, x + 150 pp. $5.00.

Unlike Pólya and Szégö's classical problem collection, this one presents problems which are still unsolved. In spite of having unsuccessfully tried most of them himself, the author estimates their difficulty as "medium". Indeed, two of the questions were answered while the book was in proof. Most of the problems were invented by the author and the collection strongly reflects the author's own mathematical interests. There was, for example, no attempt to include any of the famous unsolved problems or even to select only important problems. For such a personal collection the range of fields covered is large (set theory, algebra, topology, analysis, theoretical physics, computing). Many problems are broader than specific theorems for proof. For example, the author asks if the magnetic lines of force produced by a current flowing in a knotted wire may not have interesting topological properties. Usually a broad question is raised (with suitable background material) and then some specific conjectures are offered as problems. Mathematicians enjoy the one-upmanship of solving problems others have posed. For that reason at least these problems will probably receive much attention. Beyond that, solutions of these problems would be worthwhile mathematical achievements. Formulating good problems is an important part of mathematics; this book is a welcome contribution.

E. N. Gilbert, Murray Hill, N. J.

304:

• Landau, Edmund. **Grundlagen der Analysis** (Fundamentals of analysis). Chelsea Publishing Co., New York, 1960, 173 pp. $1.95. (German)

This classic on the foundations of analysis discusses the number system. It is also a classic of clear writing in German and has long been used by students to brush up for language exams. However, except for the specialist, it becomes rather dull reading after the same techniques are used for the *n*th time. Some 73 definitions and 301 theorems can also be deadly to the interested reader who wants to know the motivations behind the facade of theorem, proof, theorem, proof, . . .

R. W. Hamming, Murray Hill, N. J.

305:

• Say, M. G.; Haley, A. C. D.; and Scott, W. E. (Editors). **Analogue and digital computers.** Philosophical Library Inc., New York, 1960, 8 + 308 pp. $15.00.

This is another book which spends loving care on the hardware of computers and pays scant attention to the way it is used or the applications made. Indeed, only one chapter of 21 pages is devoted to programming, and even the elements of automatic coding starts eight pages from the end of the book. (Judging by page 300, the authors are unaware of compilers.) The range of current applications is completely ignored.

Richard W. Hamming, Stanford, Calif.

306:

• Goldberg, Samuel. **Probability, an introduction.** Prentice Hall, New York, 1960, 9 + 322 pp. $7.95.

This book is well described in the preface where the author says, . . . "It seemed to me worthwhile to bring the theory of probability to the attention of those who do not have the calculus prerequisite. It was with this aim in mind that I limited myself to those topics that are accessible to readers with only a good background in high algebra and a little ability in the reading and manipulation of mathematical symbols. The consequent limitation to finite sample spaces, although severe, facilitates a careful logical treatment of the essentials needed by all who use probability concepts." Feller's classic book on probability showed how far one could go in making the presentation simple when the sample spaces are countable; Goldberg's book shows the similar great forward that can be made in elementary presentation by limiting the subject to finite sample spaces. The book is well organized, well written, with many well chosen examples, and is very suitable for the non-mathematical specialist.

Richard W. Hamming, Stanford, Calif.

307:

Abstracts of current computer literature. *I. R. E. Transactions on Electronic Computers*, Vol. EC-8, 1959.

A continuing sequence of abstracts of current computer literature, in the areas of equipment, systems, automata, programs, and mathematics-logic, is being published in this journal. The sequence published in 1959 contains 542 abstracts. The abstracts and associated subject and author induces are prepared on a commercial basis by a commercial organization, with local editorial support from members of the Lincoln Laboratory, M.I.T. This commercial organization has advertised publication of the computer abstracts from 1959 and 1960 in the form of "Computer Abstracts on Cards". *Computing Reviews* will try to review the latter when they become available. The abstracts published generally consist of two- or three-sentence descriptions of the articles. *The Editors, CR*

308:

Hungarian Technical Abstracts **2,** 1 (1959).

Hungarian Technical Abstracts is a bulletin issued quarterly by the Hungarian Central Technical Library in three languages—English, German and Russian. It contains abstracts of the most significant work appearing in

other publications of the Hungarian Academy of Sciences, of Hungarian universities and in Hungarian technical periodicals. Abstracts of publications of scientific institutes and of dissertations by degree candidates are also included. Besides the publication of abstracts of Hungarian literature, the Hungarian Central Technical Library also abstracts and publishes articles from over 2,000 foreign technical periodicals, grouped in 12 classifications, in a publication called *Foreign Technical Reviews*. Abstracts in *Hungarian Technical Abstracts* are classified as mathematics, geometry, physics, mechanics, chemistry, chemical technology, geology, hydrology, hydraulic engineering, machines, energy, mechanical technology, electrical engineering, electronics, telecommunications, mining, foods, metallurgy, foundry, construction, transport, and light industries. This issue contains 127 abstracts on 18 pages, with 16 pages devoted to a list of other significant Hungarian technical articles. *The Editors, CR*

309:

• LAURIE, EDWARD J. **Applications of domestic digital computing systems in businesses and schools of business.** South-Western Publishing Company, Cincinnati, 1960, 67 pp.

This monograph is an abstract of a thesis prepared at the University of California at Los Angeles for a Doctor of Education degree. In preparing the data for this thesis, the author relied heavily on two types of samples: samples of business users of computers, and samples of schools of business. The most interesting parts of the monograph are the statistical tables summarizing aspects of the responses to sampling questionnaires. In the interpretation of the data the author recognizes the fluid state of the field and the disparity of opinion in the schools of businesses about the teaching of data processing and computers. The monograph includes a selected bibliography.

Ned Chapin, Menlo Park, Calif.

DIGITAL COMPUTER COMPONENTS AND CIRCUITRY

310:

TALANCEV, A. D. **Analysis and synthesis of certain electric circuits by means of special logical operators.** *Avtomat. i. Telemeh.* **20** (1959), 898–907. (Russian. English summary)

For the analysis and synthesis of sequential circuits whose transitions take place only at multiples of a clock time interval, the author introduces two special operators d and D, which indicate special kinds of differentiation with respect to time. These operators d and D are applicable both to Boolean functions $X(t)$ of time which remain constant from one clock pulse time to the next, and to Boolean functions $Y(t)$ which take on the value 1 only for brief pulses at clock pulse times. Unlike the customary Boolean difference, these operators have the property that any Boolean function Z of time satisfies $d^2Z = 0$ and $D^2Z = 0$. Also d has the property that not all Boolean functions $Y(t)$ have corresponding "integrated" functions F such that $Y = dF$. This paper gives a procedure for solving Boolean equations to perform the integration whenever this is possible, and uses this procedure to design an example of a circuit. *Edward F. Moore*, Murray Hill, N. J.

Courtesy *Math. Reviews*

311:

MOISIL, GR. K. **Study of the real behavior of relay-contact schemas with the help of three-valued logic.** *Bull. Math. Soc. Sci. Math. Phys. R. P. Roumaine* (N.S.) **1** (49) (1957), 145–194. (Russian)

Ordinarily, two-valued logic is used to express the two stable states of a relay, but it does not adequately represent the transient behavior of a relay circuit during the time that a relay is changing its state. The make and the break contacts of the same relay may momentarily both be open, even though when the relay is in either stable state the hindrance of one contact is the negation of the hindrance of the other. Frequently relay circuits have been designed by methods which ignore this complication, and any behavior of the circuit which unexpectedly causes difficulty because of this intermediate transient position of the relays is called a hazard. This paper gives a presentation of a three-value logic of Łukasiewicz, and shows how to obtain facility in algebraic manipulation by the use of a number of theorems given in detail. This logic is used to analyze the behavior of several simple examples of sequential relay circuits. The paper refers to several other papers making similar use of three-valued logics. See also Huffman [*J. Assoc. Comput. Mach.* **4** (1957), 47–62], which has become the customary American treatment of hazards, but without using three-valued logic.

Edward F. Moore, Murray Hill, N. J.

Courtesy *Math. Reviews*

312:

•**Proceedings of an international symposium on the theory of switching. Part I and Part II.** The Annals of the Computation Laboratory of Harvard University, No. 29, Harvard University Press, 1959.

This is a collection of 39 papers presented at Harvard University in the Spring of 1957. The symposium was attended by some 800 people from universities and industry here and abroad.

To give the readers an idea of the scope of the symposium, we will mention here participation from outside the United States. There were 11 papers from institutions abroad. These include papers by van der Pol from Switzerland; Gavrilov, Povarov and Roginskij from U.S.S.R.; Kjellberg from Sweden; Kurepa from Yugoslavia; Svoboda from Czechoslovakia; Belevitch from Belgium; Santesmases from Spain; van Wijngaarden from The Netherlands; and Walther from Germany. At the symposium it was announced, regretfully, that the authors from U.S.S.R. were not able to participate personally. A number of staff members of Harvard Computation Labs., however, presented translated versions of the Russian

papers. There was therefore no loss of continuity so far as the dissemination of technical material is concerned, although the presence of the authors would have further enlivened the international and scientific atmosphere.

Because of the size of the two volumes, it will not be practical to discuss here each of the papers in detail. We will give therefore only short reviews of the longer papers and limit ourselves to brief discussions of the rest of the contributions.

We will begin with the longer papers which contain mostly results that have been hitherto unpublished. These will be discussed in the order in which they occur in the two volumes.

In the paper, "Analytic Treatment of Real Functions Given in Discrete Points Only," Balth. van der Pol gave a number of ingenious maneuvers by which analytic identities could be derived. In one of these, the author began with a power series representation of an analytic function. Assuming the coefficients of the power series as well as certain local behavior of these coefficients are known, the author was able to obtain a number of interesting identities involving the Bessel and the Legendre functions. Elsewhere, the author showed how similar techniques can be used to obtain the Laplace transform of the Riemann zeta-function and to obtain interesting identities arising from the sampling theorem in communication theory.

"Algebraic Topological Methods in Synthesis" by J. Paul Roth is one of a series of papers by the author on the subject of applying algebraic topological methods to the synthesis of switching circuits and switching systems. In the present paper the author presented two algorithms for finding, among equivalent Boolean functions in normal form, one which has a minimum number of literals.

In "The Decomposition of Switching Functions," Robert L. Ashenhurst gave a comprehensive treatment on disjunctive decomposition of switching functions. A switching function f of a set X of n variables, $X = \{x_1, \cdots x_n\}$ is said to have a simple disjunctive decomposition if, for some disjunctive partition of these n variables:

$$X = Y \vee Z, \qquad Y = \{x_{i_1}, \cdots, x_{i_s}\},$$
$$Z = \{x_{i_{s+1}}, \cdots, x_{i_n}\}$$

where $Y \wedge Z = \phi$, there exist switching functions g of $(n - s)$ variables and F of $(s + 1)$ variables such that

$$f(x_1, \cdots, x_n) = F(x_{i_1}, \cdots, x_{i_s}, g(x_{i_{s+1}}, \cdots, x_{i_n})).$$

For simple disjunctive decomposition, the author proved that a function f of n variables possesses such a decomposition if and only if a certain matrix, called a partition matrix, has not more than two distinct columns. The author also gave a number of theorems on non-simple decompositions.

In "The Logic of Fixed and Growing Automata," Arthur W. Burks presented a theory of *discrete*, *synchronous*, *deterministic* automata of both the fixed and growing kinds. In this model, each such automaton is represented by a net (circuit) in which there are present wires, switching elements, and delay elements. This model, because of the nature of the representation, is in many ways closer to an engineer's conception of the insides of a computer than other models. The author also defined several kinds of duals of well-formed nets and obtained results relating well-formed nets with their duals.

"An Algebra for Periodically Time-varying Linear Binary Sequence Transducers" by David A. Huffman is a continuation of the author's work on the synthesis of linear sequence filters. In the original non-time-varying case, the author used an algebraic-like structure consisting of a mod-2 sum operator and a unit delay operator which are applied to input and output digits of a linear transducer. These results are extended here to the *periodically time-varying* case by the addition of a new operator called a *commutator operator*. Using these operators and the original concept of a transfer ratio for linear filters, the author showed ways by which these filters may be analvzed and synthesized.

"A Theory of Asynchronous Circuits" by David E. Muller and W. S. Bartky is a comprehensive treatment on the subject of asynchronous circuits, circuits in which the dependence of circuit-states upon the relative speeds of the circuit elements has not been eliminated by means of a central clock. The authors showed that the transitions of the states (in a general sense) of an asynchronous circuit form a lattice and a subset of these circuits have corresponding lattices which are semimodular. A circuit is considered to be *speed independent* if (roughly) its ultimate behavior is independent of the speeds of its elements. One of the principal results here is that a circuit is speed independent if its corresponding lattice is semimodular. The authors also studied extensively these circuits in terms of the mathematical properties of their corresponding lattices.

In "The Application of Graph Theory to the Synthesis of Contact Networks," Roderick Gould presented an ingenious method for the synthesis of contact circuits. In the first part of the paper, the author introduced the concept of an associated switching function for a graph. Using a number of Whitney's results, the author discussed relations between graphs and their functions. The synthesis procedure itself is too lengthy to discuss here. Although not mentioned in the paper, Gould's procedure has led to several minimal 4-variable contact circuits which had not been obtained by other methods.

The paper, "Multiple-Output Relay Switching Circuits," by Peter Calingaert gives an interesting method for reducing a certain class (called A-derivable) of multiple-output circuit synthesis problems to single-output problems. If a multiple-output circuit with outputs F_1, $F_2, \cdots, F_r$ of variables $x_1, x_2, \cdots, x_n$ of this class is to be synthesized, the author considered a new function A of $r + n$ variables $F_1, \cdots, F_r, x_1, \cdots, x_n$ and showed how the single-output circuit with output A can be transformed to solve the original multiple-output problem.

In "A Mathematical Theory for the Synthesis of Contact Networks with One Input and k Outputs," Gellius N. Povarov studied first the behavior of $L(k,n)$, which is the smallest number such that at least one 1-input-k-output circuit of n variables cannot be realized with $L(k,n)$ contacts. The author also stated a number of theorems for the 1-output case (i.e., $k = 1$).

There are also a number of papers which are primarily expository or in the nature of surveys. Michael A. Gavrilov presented a comprehensive paper on "A Survey of Research in the Theory of Relay Networks in the U.S.S.R." Theordore Singer showed "Some Uses of Truth Tables." George Kurepa discussed "Sets—Logics—Machines." Warren Semon discussed a number of Matrix Methods in the Theory of Switching. "Switching Research in Spain" and "Switching Research in Germany" were presented respectively by Jose García Santesmases and Alwin Walther. Jan A. Rajchman gave a highly informative paper on the "Principles of Transfluxor and Core Circuits." Samuel H. Caldwell discussed the use of "Transistors in Combinational Switching Circuits." Morris Rubinoff reported on "Remarks on the Design of Sequential Circuits."

Several papers on new switching components were presented. B. K. Green and his colleagues discussed photochromic switches, switches involving artificial cellular structures and permselective membrane switches. Albert E. Slade described a semipermanent woven cryotron memory and discussed possible uses of such a memory. W. D. Lewis showed several ways to perform microwave combinational logic and discussed allied gain and delay problems. Herbert B. Callen studied magnetic dissipative mechanisms in the use of thin ferromagnetic films as millimicrosecond switching devices and gave theoretical evidence of feasibility and possible improvements.

In addition to these papers there are a number of shorter papers. Goran Kjellberg discussed the meaning and implications of various kinds of dependence in switching circuits. Antonin Svoboda showed a way to minimize switching functions with the aid of contact grids. Vitold Belevitch discussed relations between contact networks and networks containing rectifiers. Franz E. Hohn studied $2N$-terminal contact circuits. Robert C. Minnick presented two methods for reading or writing from or into two or more independent locations simultaneously in a matrix store and showed that with an rf-readout process it is possible to read from many locations simultaneously and efficiently. T. H. Bonn compared magnetic amplifier switching circuits with transistor circuits and showed that delays in magnetic amplifier circuits may be significantly reduced without sacrifice in gain by coil gating. William B. Cagle and Wayne H. Chen presented a new type of transistor-diode logic circuits which have significantly better high-speed characteristics than direct-coupled logic circuits. Way Dong Woo discussed logic circuits derivable from the concept of 1-core-per-bit shift registers and described trigger and counter circuits using transistor-core logic. Maurice Karnaugh described a possible way of building large magnetic selectors by combining known selectors with coincident-voltage output circuits. Bradford Dunham and James H. North analyzed multipurpose logical devices having 3 or 4 inputs as possible basic circuit building blocks. R. A. Kudlich discussed logical design considerations of various direct coupled transistor circuits. A. van Wijngaarden presented a theory of *linear boxes* in which the *total states* satisfy a certain linear equation. Sundaram Seshu and Franz E. Hohn studied symmetric polynomials over a Boolean algebra. B. D. Holbrook discussed the control of switching distribution networks. René A. Higonnet and René A. Grea suggested that sequential circuits involving a small number of relays be classified. Edward F. Moore presented a number of interesting algorithms for finding shortest routes in a maze.

As the reader can see, these two volumes constitute a comprehensive collection of worthwhile contributions.

C. Y. Lee, Whippany, N. J.

313:

GLAETTLI, H. H.; AND MUELLER, H. R. **On the possibility of hydraulic digital control elements.** *Zeit. angew. Math. Phys.* (ZAMP), **11**, (January 1960) 73–75. (German)

Representative figures for hydraulic logic elements are given. A value compares favorably with a transistor as to its logic power, and is slightly inferior to a relay. The dependence of the response time on the geometric size and the influence of the viscosity are discussed.

Courtesy *IBM J. Res. Develop.* **4**, 3 (July 1960)

314:

DICKINSON, W. E. **A character-recognition study.** *IBM J. Res. Develop.* **4**, 3 (July 1960), 335–348.

This paper reports on a study of the feasibility of machine recognition of characters using a slit scanning technique (optical or magnetic). The characters were the digits 0 through 9, and were specially designed, using some of the principles developed in the study, for easy machine recognition consistent with readability by humans. An n-vector, representing a discretely sampled wave-form of the slit output during traversal of the character, is compared with standard n-vectors selected as characteristic of the several digits.

Comparison is based, essentially, on a scalar product (small for good matching) between the standard vectors and the slit-scan output vector. A requirement that the ratio between the smallest and the next smallest inner products be less than an arbitrary amount must be met. This tends to reduce the number of "substitution" errors. If not met, a "rejection" occurs which turns the task of recognition back to a human. The particular digit type fonts used were obtained empirically by seeking large separation of character wave-form vectors—as nearly orthogonal as practicable under the constraint that the

characters must be recognizable by humans. The particular digit forms studied are not claimed to be optimum. Certain decision criteria for rejection, adjusted to the quality of printing, are proposed. The author concludes that the single-slit scan system would not be adaptable to reading alphanumeric characters also readable by humans, although it could be used to recognize the digit forms used in his study. *M. L. Deutsch*, Paulsboro, N. J.

315:

TRUBNIKOV, N. V. **Input and output of information in high-speed digital computers.** V sb.: *Avtomat. upravleniye i Vychisl. tekhn* (Automatic control and computation techniques). Moscow, Mashgiz, 1958, 223–242. (Russian)

A detailed review is given of *devices* for input and output of information in digital computers. General conditions, which the carrier of information must satisfy are: low costs, a high density of recording (the amount of information per unit of length, area or volume), durability and possibility of repeated use, indelibility of recording at prolonged storage, possibility of an easy checking and correction of recording, reliability of reading and possibility of putting together the initial documents out of separate pieces. The most frequently used are punched cards, punched tapes and magnetic tapes. Less used are magnetic wire and film. Punched cards permit recording information with a density of ∼355 signs per cm^3. The correctness of recording is checked visually or with instruments. A correction of the recording is impossible.

The costs of equipment for handling the punched cards are relatively high. Under proper conditions punched cards can be kept for a long time and used repeatedly. The speed of recording on punched cards is ∼15–20 numbers per second, and the speed of reading (when photodiodes are used) is ∼180 numbers per second. The reliability of devices for handling punched cards is fairly high. Punched tapes are used with widths of 5–182 mm. and have correspondingly 1–90 tracks. The most used are punched tapes with a width of 12 mm (2 tracks), 17.5 mm. (5 tracks) and 35 mm. (12 tracks). The storage conditions, multiplicity of use and possibility of reproducing the information from damaged punched tapes are about the same as for punched cards. The complexity of equipment depends on the width of punched tapes. The costs of equipment for narrow punched tapes are low. To prolong the life time of punched tapes the information is read by means of photodiodes at a speed of ∼150–200 40-digit numbers per second for a 5-track punched tape. The speed of recording is ∼20–30 punchings per second. An advantage of punched tapes is the possibility of a repeated input of information by means of reversing or pasting into a ring which cannot be done with the punched cards.

General information regarding magnetic tapes, magnetic heads and principles of recording and reading is imparted. Mostly used are the following methods of recording: Two-level recording, at which the amplitude of the pulse read is much larger and the density of recording much lower than with other methods of recording; three-level recording, at which the absence of a number is represented by the zero remanent induction, and unity and zero are recorded by the mutually reverse magnetization (by this method the density of recording increases by about 25% and the amplitude of the signal read decreases by 30%, and the amplitude of ghost pulses decreases sharply); two-level recording without an interval between like numbers. This method requires the presence of marker pulses to determine the number of ones and zeroes in a group, as well as the absence of a digit. The method permits doubling the density of recording. The width of magnetic tapes is within 6.35–125 mm, the number of tracks is correspondingly from 1–3 to 50. Mostly used are magnetic tapes with a width of 17.5 and 35 mm with a parallel-successive method of recording. With an increased width of the tape the deformation of the magnetic tape at transport affects essentially the density of recording. The deformation of magnetic tapes causes a skewing of the line of the recorded information relative to the slots of the magnetic head. An analysis of the influence of skewings on the density of recording and on the interchangeability of magnetic tapes is given. Data on the influence of the design of the magnetic head assembly on the accuracy of adjustment of an imaginary ideal line are supplied.

Tests of home and foreign magnetic tapes have shown that they must have a mechanical strength of ≧5 kg at a width of 6.35 mm. and a stretchability of ≦0.1% per unit of length; physical and geometric parameters must be uniform; the size of grains of the magnetic coating must be ≦0.1 micron; the surface of contact with the magnetic head must be polished. The costs of magnetic tapes are low, the density of recording is 5,000–50,000 signs per cm^3 at the thickness of tape of 0.05–0.12, step of recording 0.5–0.08, and width of track 1–2 mm. Storage time of magnetic tapes is several years. The design of mechanisms for drawing magnetic tapes is simple in principle, but requires a precision in manufacturing. An increase in reliability leads to a decrease in the density of recording and to a more complicated equipment. Briefly, devices for preparing and recording the initial information on the carriers and for the printing of results are described. 18 illustrations.

(Translated from *Referativnyi Zhurnal, Elektrotekhnika*, 1959, **22,** p. 127)

DIGITAL COMPUTER PROGRAMMING

316:

ZHOGOLEV, E. A.; ROSLYAKOV, G. S.; TRIFONOV, N. P.; SHURA-BURA, M. R. **Sistema standarnykh podprogramm** (A system of standard subprograms). Edited by

M. R. Shura-Bura. Biblioteka Prikladnogo Analiza i Vychislitel'noi Matematiki. Gosudarstv. Izdat. Fiz.-Mat. Lit., Moscow, 1958. 231 pp. 6 rubles, 10 kopecks. (Russian)

A system of standard subroutines for the Soviet computer M-2 (STRELA ?) at the Moscow State University Computation Center is described in very thorough detail, in fact the most thorough of any book on computers since the earlier works by Wilkes, Wheeler, and Gill on the EDSAC. There is a very detailed description of the machine M-2, which has a cathode-ray-tube storage, and of basic programming for that machine. There is a description of the method of logical program schemes (apparently first due to Lyapunov) and of how standard subprograms may be used with it. The remainder of the book is a detailed description of the subroutines for floating point operation and separately for fixed point operation, including the standard functions, input-output, and number conversion in both cases. Finally subroutines for Runge-Kutta numerical integration of ordinary differential equations, Simpson's rule, and solution of systems of linear equations are included.

The work described was apparently done in 1955–1956. There appears to be no major contribution as far as methods of approximations, etc., over what has been done in computation centers in the United Kingdom and U.S.A. up to that time. Nevertheless, the book deserves recognition as a very thorough documentation of the work of one computation center using a specific machine.

John W. Carr III, Chapel Hill, N. C.

Courtesy *Math. Reviews*

317:

STEIN, MARVIN L.; AND ROSE, JACK. **Changing from analog to digital programming by digital techniques.** *J. Assoc. Comput. Mach.* 7, 1 (January 1960), 10–23.

The theory and techniques for using the programs already set up for analog computation to write digital programs is presented by the authors. Their approach is to analyze the set-up diagrams representing systems of differential equations. The equivalent digital expressions are derived for each circuit element. Therefore, any combination of the set-up diagram elements can be equated into the digital format by substitution. The rules and procedures for performing the substitution process are discussed in detail. The flow diagram for a digital program is made up to exemplify how to convert a typical analog program by digital techniques. In general, this article supports the premise that digital techniques can be used to change from analog to digital programming, but it does not elaborate on many of the details required to perform this task. *V. A. van Praag*, Los Angeles, Calif.

318:

ECKTON, ARTHUR. **650-Simulator for the scientific Univac.** Boeing Airplane Company, Seattle, 1958, 76 pp.

This report describes a program for simulating a basic IBM 650 on the UNIVAC Scientific 1103A. It includes program flow charts, but it is mainly a programmer's manual. The program includes some diagnostic routines and also the simulation of some standard 650 control panels. Other panels can be simulated by giving their specifications to the program in a very general way.

Harold R. Van Zoeren, Pittsburgh, Pa.

319:

LYNCH, WILLIAM C. **Coding isomorphisms.** *Comm. ACM* **3,** 2 (February 1960), 84–85.

The paper presents a specialized application of analyzing a problem in light of the solution media. The gain from handling information organized in machine-oriented mode rather than a humanly-oriented mode is pointed out.

F. A. Williams, White Plains, N. Y.

320:

BEMER, R. W. **A proposal for character code compatibility.** *Comm. ACM* **3,** 2 (February 1960), 71–72.

A method is suggested for phasing out the many old character code sets in existence. This is vital to the adoption of a new logical code set, particularly for data processing. The concept is to have parallel standards, such as Baudot, Fieldata, IBM, etc., but to be able to move dynamically from one standard to another by reserving in each set a single character which has no other function but to signal as "escape" mode. The subsequent character (although it normally has other significance in the set) then identifies the particular standard which is to be in force. It is thus possible to have 2^T different sets of 2^T characters in a T-track code.

Courtesy *IBM J. Res. Develop.* **4,** 3 (July 1960)

DIGITAL COMPUTER PROGRAMMING (LANGUAGES)

321:

●SCHWARTZ, J. I.; PETERSEN, K. E.; AND OLSON, W. J. **Jovial and its interpreter, a higher level programming language and an interpretive technique for checkout.** [Paper SP-165] System Development Corp., Santa Monica, Calif., 1960, 39 pp.

JOVIAL (reportedly standing for "Jules [Schwartz'] Own Version of I.A.L. [now ALGOL]") is the language of a system for coding and checking programs for SAC's Military Computer (the AN/FSQ-31). It is based on ALGOL but has provision for detailed description and manipulation of some specific types of data. The major functions of the system described in this paper are: (1) to convert programs written in JOVIAL to an intermediate language, (2) to convert data to be used as a test environment, (3) to execute the program interpretively on the IBM 709, (4) to print out actual results and expected results side-by-

side. The purpose of the interpreter is to make possible the checkout of programs for the Military Computer before that computer actually becomes available.

The JOVIAL system represents a workable system as advanced as the state of the art and the limitations of time and manpower admit. While it eases the task of program coding, it does not aid the even larger task of program design. The interpreter feature contributes to checkout by providing many of direct checks for coding errors and by providing for monitoring of program execution by snapshotting or tracing. On the other hand, JOVIAL notation contains unusual symbology because of the lack of an adequate character set. The language is billed as a "higher-level programming language", meaning that it aspires to be a language independent of any specific computer. Upon examination it is apparent that while most of the expressions in the language can be regarded as machine-independent, they are for the most part confined by the data descriptions to a limited set of techniques for carrying out operations on a specific computer. What is allowable in both the procedures and data descriptions is strongly governed by what can be executed with reasonable efficiency on a specific machine (the Military Computer). The paper itself was not readily understandable to this reviewer. It uses many terms not known outside of System Development Corporation.

Philip R. Bagley, Lexington, Mass.

322:

●ISBITZ, HAROLD. **CLIP, a compiler language for information processing.** System Development Corp., Santa Monica, Calif., 1959, 9 pp.

This short book is a description (in brief) of a data processing compiler system that is being implimented currently on an IBM 709. The nature of treatment is such that the basic compiler, when once defined in its own language, will be capable of adapting itself for another machine. The book is of interest primarily for two reasons: (1) The interesting discussion on table construction; (2) The description of the various steps taken to make CLIP as versatile as possible.

E. D. P. Gross, Jr., West Hartford, Conn.

323:

BACKUS, J. W.; BAUER, F. L.; GREEN, T.; KATZ, C.; MCCARTHY, T.; NAUR, P.; PERLIS, A. J.; RUTISHAUSER, H.; SAMELSON, K.; VAUQUOIS, B.; WEGSTEIN, J. H.; VAN WIJNGAARDEN, A.; AND WOODGER, M. **Coobshchenie ob algorithmicheskom yazykie ALGOL 60** (Report on the algorithmic language ALGOL 60). Editor, Peter Naur. Translated by G. I. Koshykhina; Editor, A. P. Ershov. Vychislitel'nyi Tsentr AN SSSR (Computation Center, Academy of Sciences, USSR), Moscow, 1960, 67 pp. Price 1 ruble, 85 kopecks. (Russian)

This appears to be a translation of ALGOL Bulletin Supplement No. 2 distributed by Regnecentralen, Valby, Denmark. The editor, in his preface, states that it was the decision of the All-Union Congress on Computational Mathematics and Computational Techniques meeting at Moscow State University in November 1959, to produce this translation. An English version in shortened form has been published in *Numerische Mathematik* **1,** (1959), 41–60, and in *Comm. ACM* **3,** 5 (May, 1960), 299–314.

John W. Carr, III, Chapel Hill, N. C.

DIGITAL COMPUTER SYSTEMS

324:

CARROLL, W. N. **Computer design for reliability.** *Electronic Equipment Engineering* **1,** (January, 1960), 69–72.

This article describes the basic circuits which are used in the RTA Computer which has been built by the Federal Systems Division of IBM. This computer, employing 20,000 high-speed PNP transistors and having three-volt signal levels and 35 mμsec pulses, is designed to operate at a 6.23-Mc clock rate and handle instructions at a rate of 300,000 to 500,000 per second.

A brief resume is presented of the computer characteristics, and the reliability, packaging and other factors which influenced the circuit design are described. The two basic circuits, pulse and saturating dc circuits and their modifications are described in detail. Inverters, flip-flops, pulse gates, slave gates, OR pulse amplifiers, and pulse amplifiers are discussed. Circuit schematics are presented along with a detailed description of the operating and design characteristics. The article also describes the operation of these circuits in a logic application.

Courtesy *IBM J. Res. Develop.* **4,** 3 (July 1960)

325:

GIL'MAN, A. M., **Nekotoryye osobennosti logicheskoy struktury mashiny GIFTI i programmirovaniya v ee kode I** (Certain features of the logical structure of the GIFTI computer and programming in its code—Part I) *Izvestiya vysshikh uchebnykh zavedeniy* (Journal of the Higher Institutes of Learning), Radiofizika, Nr. 1 (January 1958), 141–149, Gor'kiy University Press. (Russian)

This paper, apparently the publication of a thesis, follows naturally an early paper by the same author, "K *proektu vychislitel'noy mashiny posledovatel'nogo tipa*" (The design of a sequential type computing machine), in the proceedings of the Konferentsiya "Puti Razvitiya Sovetskogo Matematicheskogo Mashinostroeniya i Priborostroeniya", Sektsiya Universal'nykh Tsifrovykh Mashin, Chast' I (Conference, "The Way to Development of Soviet Mathematical Machine and Instrumentation Construction", Section on Universal Digital Computers, Part I, Moscow, 12–17 March, 1956; see Review 333, CR, this issue). The author places most stress on the facility of the GIFTI computer for "readdressing", i.e. using index registers. There are six such cells in the "high-speed" (drum recirculating) memory, and it is possible with one instruc-

tion to add such an index register to the contents of an instruction in a main memory location, perform the instruction, increase the contents of the index register, and if necessary clear another such register. The basic interest of the paper is this readdressing technique, and the use of single-length and double-length words, similar to that originally developed on the EDSAC in Great Britain in 1950. Beyond this, a fairly complex analysis is carried out of the translation from the standard Lyapunov "operator method" of programming over into the machine code, which would indicate that a compiler-translater may have been constructed, particularly since the term "programming program" is used. This analysis includes techniques of taking advantage of the machine code to eliminate coding duplications, and an algorithm for optimization of index registers within the frame-work of this three-address instruction code is tentatively implied. A block diagram of the computer is included. Since it is a drum machine, and a large search time of the main memory is quoted, the computer would be of most interest for its elaborate instruction nature, its "sliding binary point" allowing various scaling, and the possible technique for translation from Lyapunov notation into machine language.

John W. Carr, III, Chapel Hill, N. C.

326:

SCHAFFER, ROBERT R. **A magnetic drum memory with a one megabit storage.** *Electronic Industries* **19**, (March 1960), 114–117.

Design engineers took an existing magnetic drum memory and increased its capabilities eight times. Their ideas and innovations, given here, will prove useful to other design engineers.

Courtesy *Battelle Tech. Rev.* **9**, 6 (June 1960)

327:

ENGLAND, J. L. **The U.C.T. in Europe.** *Comput. Bull.* **3**, 5–6 (March 1960), 79–82.

This paper reports on a visit to two European installations which use the "UNIVAC 90" or UCT computer in their daily business operations. In the U. S., this computer is referred to as the "Solid State 90." It represents Remington Rand's answer to the IBM 650 computer in that it is a magnetic drum machine. The paper gives a completely adequate description of the "90" computer used in these two locations. If this were not contained in a computing journal, this reviewer would consider it advertising material.

T. D. Mueller, San Francisco, Calif.

328:

● IVALL, T. E. **Electronic computers, principles and applications.** Philosophical Library, New York, 1960, 2nd ed. 263 pp. $15.00.

Evolution of the computor, general principles of computation, analogue computing circuits 1 and 2, equipment of analogue computers, applications of analogue computers, digital computer circuits 1 and 2, storage systems, digital computer equipment and other problems are discussed.

Courtesy *Battelle Tech. Rev.* **9**, 6 (June 1960)

329:

ROBINSON, L. W. **The ICT 1301 data processing system.** *Comput. Bull.* **4**, 1 (June 1960), 29–31.

The English ICT-1301 is the latest of a group of medium-sized but high-speed, fully transistorized, modular computer systems especially aimed at industrial and commercial data processing. The basic ICT-1301 uses punched cards as its input medium and has a core storage of 400 12-decimal digit words as well as a 12,000 word rotary magnetic drum. The core storage can be increased to 2,000 words in steps of 400, while up to seven additional drums can be added. One to eight magnetic tape drives can also be added to the system. Its basic add time is 21 microsec. The news release published in the ONR Digital Computer Newsletter (*Comm. ACM* **3**, 7 (July 1960), p. 452) contains essentially all the information in the original paper except for a table of cost figures. Two examples: The basic machine costs 65,000£ ($182,000). A machine with 1 drum, 1200 words of core, and 5 tapes would cost 146,000£ ($410,000). No delivery times are given.

Harwood G. Kolsky, Omaha, Neb.

330:

GIL'MAN, A. M. **K proektu vychislitel'noy mashiny posledovatel'nogo tipa** (The design of a sequential type computing machine), in the proceedings of the Konferentsiya "Puti Razvitiya Sovetskogo Matematicheskogo Mashinostroeniya i Priborostroeniya", Sektsiya Universal'nykh Tsifrovykh Mashin, Chast' I (Conference, "The Way to Development of Soviet Mathematical Machine and Instrumentation Construction", Section on Universal Digital Computers, Part I, pp. 82–91, Moscow, 12–17 March, 1956. (Russian)

The author, representing the Ministry of Higher Education of the USSR, and in particular the GIFTI (Gor'kiy Physical-Technical Research Institute) describes the design of a sequential, binary, digital computer. It is not apparent whether it was in operation at the time of writing the paper. The machine uses a magnetic drum storage of 1984 words of 32 bits each (usually commands) but also can have 992 words of 64 bits each, usable as numbers. There is a 31-word high-speed recirculating memory of 64 bits each. The fixed point may be located at 5 different positions in a word, decided upon at the beginning of the computation.

Each instruction contains three addresses, the first referring to the main memory (plus high-speed memory), the last two addresses to the high-speed memory only, six of whose cells are used as index registers. The instruction is thus actually one-address. There are about 32 different operations, with at least a dozen variants, using the index registers, on each of these. Efficient subroutine entry is provided. A code for matrix multiplication, using fourteen instructions, is included in the paper. It is stated that for

solution of linear systems of order $n = 18$, the time taken requires about 4 minutes. The speed of drum revolution is not given. The purpose of this machine was apparently for low-cost engineering calculations, although the number of vacuum tubes is not listed to offer any possible comparisons. *John W. Carr, III*, Chapel Hill, N. C.

331:

RADIMOV, O. N. **On the quantitative estimate of operating reliability of computer systems.** *Isvestiya Akademii nauk SSSR, Otdeleniye tekhnicheskikh Nauk, Energetika i Avtomatika* (Proceedings of the Academy of Sciences, Division of Technical Sciences, Energetics, and Automation), 1960, Nr 2, 173–176. (Russian)

In the investigation of reliability of computer systems the following assumptions are made as to the statistical character of faults: (1) two events cannot occur at the same instant of time; (2) the faults are independent; (3) the process is stationary—the probability of a fault is stationary—the probability of a fault is stationary in time. In real machines these assumptions are not completely valid. When neglecting restoration, then the technical reliability is the probability that the system will operate from the placing into operation to the first fault for a time greater than a given time. When repairs are considered, the operating reliability is the probability that the system will be in the operating state for a time greater than a given time. Since the machine may fault even when not in operation (e.g. semiconductors), it is necessary to consider the probabilities of faults both during operating and non-operating periods. The numerical value of operating reliability is defined by expression (5). The parameters of this expression may be determined from the reliability statistics of actual machines taken over a period of time. When a machine is easily repaired it may have a high technical reliability even if the fault rate is high. On the contrary, if it is not easily repaired it may have a low operating reliability even with a low fault rate. There are four Soviet references.

(*Translated from the Abstract*)

332:

LUND, GEORGE E.; AND FAULIS, DONALD R. **Expandable random access memories.** *Electronics*, **33,** 11, (March 11, 1960), 164–166.

These expandable solid-state memories operate in an ambient temperature of from 15 to 55 C and require no better than plus or minus three percent supplies. Plug-in feature provides unusual economy.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

333:

RONNE, JAMES S. **Computer switching with high-power transistors.** *Electronics* **33,** 10 (March 4, 1960), 44–47.

The problem how to select the right power transistor and switching circuit to obtain required switching speed, gain and current-carrying capacity is discussed in detail.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

334:

HUNGERFORD, H. R. **The multi-dimensional LARC.** *Univac Review* **2,** 3 (Fall 1959).

This is a four-page paper on the Remington-Rand UNIVAC LARC. This very large and very fast computer, originally designed for the Livermore Laboratory of the Atomic Energy Commission, and now available commercially. The LARC refers specifically to a system of components, variable in number but always including a central "computer" for high speed arithmetic and a central "processor" (which is also a computer) for coordinating the input-output operations. The high speed magnetic core storage may have a capacity of up to 97,500 12-digit words with an access time of 4 microseconds per word. The central computer and the processor have access to this storage unit while magnetic tape, drum storage, printer, and reader units have access to the processor. The paper has a good block diagram of an expanded LARC system and contains a brief description of the basic internal code, but it does not contain operation time data except to say that the machine is "200 times faster than any computer in existence today."

R. E. Meagher, Champaign, Ill

335:

KOZMA, L. **The new digital computer of the Polytechnical University, Budapest.** *Period. Polytech. Elec. Engrg.* **3** (1959), 321–343.

This is a description of a variable, but not stored, program, floating point binary digital computer, constructed from telephone relays by the Polytechnical University. The computer was constructed for teaching purposes, to make available an example of digital techniques for students in engineering, in order to "inculcate . . . a novel conception of switching techniques." Programs are placed in the machine on perforated "insulating materials" containing up to 45 program steps. Input-output data, via electric typewriter, is automatically converted between binary and decimal number systems. The formulation, but not programs, for determining roots of a cubic equation by Newton's method, for calculation of natural logarithms, for calculation of Erlang's formula for telephone traffic, and conversion by halving and doubling, are given. The equipment, apparently comparable to the U. S. relay computers of about 1948, is not the only one in Hungary. A more modern equipment has been stated as being in process of construction by the Institute of Cybernetic Research.

John W. Carr, III, Chapel Hill, N. C.

Courtesy *Math. Reviews*

336:

RECOQUE, ALICE; AND BECQUET, FRANCOISE. **CAB 500, petite calculatrice arithmetique scientifique** (CAB 500, small arithmetic scientific computer). *Chiffres* **2,** 2 (June 1959), 65–75. (French)

This paper is essentially an announcement of the completion by S.E.A. of a medium capacity digital computer designated the CAB 500. The machine utilizes magnetic-core logical elements with printed-circuit wiring, a mag-

netic drum, and perforated tape or electric typewriter for input and output. The basic word length is 32 bits with two additional bits used for transfer to the drum. The drum has a storage capacity of 16,000 words and an average access time of 10 milliseconds. A high-speed memory of 16 words is also included. Circuitry is provided for direct execution of 13 simple arithmetic and logical orders, each requiring 340 microseconds. More complex orders, including multiplication and division, read-in and print-out, are carried out by reference to microprograms stored permanently on the drum. These require 20 to 60 milliseconds for execution but are programmed in the same manner as the simple orders. A simple switch permits conversion of the machine to a desk calculator with input and output by means of the electric typewriter. No details of the machine capabilities in this mode of operation are given.

W. W. Seifert, Cambridge, Mass.

337:

Leiner, A. L.; Notz, W. A.; Smith, J. L.; and Weinberger, A. **Pilot—a new multiple computer system.** *J. Assoc. Comput. Mach.* 6, 3 (July 1959), 313–335.

(Rev. No. 4401, *Appl. Mech. Rev.* **13,** 9 (September 1960) 626)

338:

Brooks, F. P. **The execute operations—a fourth mode of instruction sequencing.** *Comm. ACM* **3,** (March 1960), 168–170.

Instruction sequencing modes include normal sequencing, branching, interruption, and use of Execute operations whereby an addressed instruction is executed out of its normal sequence. Execute operations essentially serve as calling sequences for one-instruction subroutines, and this property suggests a variety of applications. The two Execute operations provided in the Stretch computer are described.

Courtesy *IBM J. Res. Develop.* **4,** 3 (July 1960)

DIGITAL COMPUTER TECHNIQUES

339:

Tou, Julius T. **Digital and sampled-data control systems.** McGraw-Hill, New York, 1959, 631 pp. Continuous-data control systems; basic theory of sampling and quantizing; frequency domain analysis; z-transform analysis; transient response and system-error analysis; analog-digital conversion principles; general design principles.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

340:

Voronov, A. A.; and Sokolov, G. N. **Digital integrator device for programming second-order curves.** *Automation and Remote Control* **20,** 2 (January 1960), 169–176. (Translation of *Automatika i Telemekanita, USSR* **20,** 2 (February 1959), 176–183, by Instrument Society of America, Pittsburgh 22, Pa.).

(Rev. No. 4400, *Appl. Mech. Rev.* **13,** 9 (September 1960), 625–626)

INFORMATION STORAGE AND RETRIEVAL

341:

Cockayne, A. H.; and Hyde, E. **Prime number coding for information retrieval.** *Comput. J.* **3,** 1 (April 1960), 21–22.

The authors describe their mechanization of a small file of about 25,000 items, representing organic chemicals, consulted about 80 times a day. The items are specified and requested by simple combinations of less than 20, usually less than 10, structural features out of 250 distinct features. Till now, searches have been carried out by using a punched card select-sorter on an auxiliary file of punched cards.

When considering operation of the system by magnetic tape and computer search, the authors use the prime-factors system, which they believe to be novel but which originated with Leibnitz in 1679. The method entails both an arithmetical computer, instead of pattern matching devices, and, because of the largely empty vocabulary, 76-bit words (as opposed to the 30 to 40 bits required by other methods when applied to a collection of only 25,000 items). Using magnetic tape in a "Pegasus," which is a rather slow scientific computer, the authors can test each item, for a single request only, in 6 milliseconds. (For comparison, the reviewer would point out that a single operator using a properly organized marginally-punched card file averages around 100 milliseconds a test.) Once the selected serial numbers have been printed out, the main document file must still be consulted for the required information. (This might not be necessary for most semi-manual systems, which supply data as well as index.)

The paper contains no references, explicit or implicit, to other work in the field of documentation in general, or mechanized retrieval in particular. In this scheme, the reviewer can find neither merit nor motivation, other than a determination to use automatic machinery at all cost. This cost could be reduced to one-fifth to one-tenth, for the same output, by known semi-manual or even manual methods, or by properly coding it as a part-time job on a next-generation computer. The authors have not organized the basic information file rationally. As the specifications are simple combinations from a fixed field of components they can be arranged linearly without ambiguity, e.g. by listing components in ascending order of frequency of occurrence, and then ordering the file lexicographically with respect to these lists. With 25,000 items no auxiliary searching would be needed. Second, they have ignored the fundamental difference between codes for possible description, and codes for actual selection. The last must be matched to the size of the actual collection, e.g. only if the collection contained one million to ten million items would a 76-bit code be needed. *R. A. Fairthorne*, Farnborough, England

342:

• Barden, William A.; Hammond, William; and Heald, J. Heston. **Automation of ASTIA.** Armed Ser-

vices Technical Information Agency, Arlington, Va., 1959, 50 pp. $1.25.

This document consists of three related but independent papers concerning the history, problems, accomplishments, and future goals of the Armed Forces Technical Information Agency. In Section I, "Early Considerations of Automation," Barden presents a brief, interesting history of ASTIA and of the studies and programs directed toward providing better, faster, more effective services. This section concludes with the statement that selection of equipment for the present ASTIA automation has been guided by study-program results showing that the relatively conventional "business type" functions of ASTIA were the most important ones to automate first in order to improve service and conserve manpower. The more sophisticated "information retrieval" functions were considered candidates for later automation, and were apparently quite secondary in guiding the choice of equipment.

In Section II, "The ASTIA Automation Program," Hammond clearly describes in some detail the actual functioning of ASTIA in receiving and cataloging documents, preparing and distributing abstracts, and processing user requests for documents under preautomation conditions. He then describes the steps actually taken to meet the specific automation objectives chosen by ASTIA. A UNIVAC Solid State 90 Computer was chosen to implement the automation program in three stages which were to be related to the amount of equipment installed and in use. In the first stage the computer was to be operated with punched card input and output, in the second stage, magnetic tape facilities were to be added, and in the third stage a Randex random-access memory was to be added. As the successive stages of operation are achieved, additional functions are automated and greater operational speeds are expected. The author concludes his section of the publication with a description of plans for certain changes in ASTIA publication policies as a result of the automation program. For example, the bimonthly *Technical Abstract Bulletin* will eventually announce acquisitions 20 to 25 working days after receipt in contrast to the preautomation 60 days. Subject and Corporate Author Indexes will be eliminated from the bimonthly Bulletin and will appear in quarterly and annual Cumulative Indexes.

In Section III, "Creation of a System of Machine Retrieval Terms," Heald describes Project Mars, created to solve "the most subtle of all problems," identification of the subject matter of ASTIA documents in a manner suitable for automatic machine retrieval. A careful study of existing retrieval techniques by a team of senior ASTIA personnel and consultants resulted in adoption of "Descriptors," based upon an extensive revision of the Subject Headings previously used by ASTIA. The objective is to assign to each document a set of descriptors (averaging about eight per document) which will permit machine retrieval of documents in response to complex reference questions and bibliography requests.

The problems, studies, and solutions covered in this report are all very interesting. It will be equally interesting to learn of the actual operating results of the automated system, particularly in the less conventional area of information retrieval. *Benjamin Kessel*, Framingham, Mass.

INFORMATION THEORY AND CODING

343:

MEGGITT, J. E. **Error correcting codes for correcting bursts of errors.** *IBM J. Res. Develop.* **4,** 3 (July 1960), 329–334.

The author considers a class of error-correcting codes described by the equation

$$a_1x + a_2Tx + a_3T^2x + \cdots + a_nT^{n-1}x = 0,$$

where $a_1, \cdots, a_n$ are successive bits in a transmitted block, k of which are check bits; x is a $k \times 1$ vector representing the state of a shifting register; T is a $k \times k$ matrix of 0's and 1's which related successive states of the register; and $T^n = I$. The principal contribution is to recognize that the characteristic equation of the matrix T is invariant under a similarity transformation. One can therefore choose from among a set of similar matrices that one which is most suitable for implementing a particular code. The process is illustrated by several examples, among them being the codes of Abramson, Melas, and Fire. *Robert N. Goss*, San Diego, Calif.

344:

ABRAMSON, N. M. **A class of systematic codes for non-independent errors.** *IRE Transactions on Information Theory*, **IT-5,** 4 (Dec. 1959), 150–157.

A class of systematic codes was obtained which will correct all single errors and all double errors which occur in adjacent digits. These codes use significantly fewer checking digits than codes which correct all double errors. In addition, because of inherent regularities in their structure, these codes may be instrumented in a strikingly simple fashion.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

345:

HOCQUENGHEM, A. **Codes correcteurs d'erreurs** (Error Correcting Codes). *Chiffres* **2,** 3 (September 1959), 147–156. (French)

This paper generalizes the work of Hamming (*Bell System Tech. J.* **29** (1950), 147–160). To transmit words of $2^n - 1$ binary bits and to detect and correct k errors requires that nk of the $2^n - 1$ bits transmitted to be test bits. This would check only the $2^n - 1 - nk$ bits of information, not the test bits themselves. The author gives an example of a 15-bit code correcting two errors (8 test bits, 7 information bits). This involves the construction of an 8×15 matrix, the inversion of a matrix

of order 8, and the product of this inverse and the 8×15 matrix. The arithmetic is in the integral domain of all polynomials in one variable over the prime field of characteristic 2. *A. Newhouse*, Houston, Tex-

346:

SIMON, HERBERT A. **Some further notes on a class of skew distribution functions.** *Information and Control* **3,** 1 (March 1960), 80–88.

The article concerns the by now well-known attempts to explain the linguistic data collected by Zipf (as well as data from other fields such as biology or demography) by means of stochastic or, alternatively, by means of "teleological" rationales. Specifically, in the article, Simon defends the stochastic point of view and the steady-state functions developed from this point of view against she specific criticisms brought against the stochastic conception by Mandelbrot in an earlier article. The assumptions needed by Simon to generate the steady state distribution for word frequency data are: (1) that the greater the total occurrence of words in a class i among k words in a sample, the greater the likelihood that the $(k + 1)$st word will be in class i; (2) that there is a constant probability that the $(k + 1)$st word will be a new word. (An author chooses his words partly by association—tending to repeat words which he has already used—and partly by imitation—tending to select words commonly used.) One of the criticisms of Mandelbrot's against Simon's mathematical derivations for the steady state distribution is that the range of values of ρ assumed by Simon (i.e. the value of the exponent of the distribution function) does not generally obtain in linguistic data. Specifically, the expected value of i for the formulae presented by Simon in an earlier article is finite if and only if $\rho > 1$. With regard to this particular and primary criticism Simon proceeds to show that, at least for Zipf's data, $\rho > 1$ more often than not and that it is almost always very close to 1. He then proceeds to generalize his earlier formulation to a function which has $\rho < 1$. Simon concludes that his stochastic interpretation is more adequate than Mandelbrot allows. On the side of the assumptions underlying the rivaling models, Simon points out that his own model has the advantage over that advanced by Mandelbrot in that it requires no assumptions about the statistical properties of the alphabet in which the words are encoded. All in all, the evidence presented by Simon suggests, at least to this reviewer, that his stochastic model is a serious competitor indeed to the opposite attempts which are to explain the data by means of a theory regarding the information and the cost inherent in communication. Until further experimental evidence to the contrary is produced, even the argument that the "teleological" model might lead one to uncover important theoretical dimensions has not as yet borne any fruits. Simon refers to data indicating that, at least for a conception of "cost" based on word length, the data support as much the contention that use encourages the user to abbreviate the length of his words as the contention that shortness of a word favors its use by the communicator. Hence, a purely stochastic process may not be ruled out. Nevertheless, it still remains intriguing that Mandelbrot was capable of generating the steady-state distribution by means of certain underlying "laws" of communication. Since it is clear that even the stochastic model rests on certain, albeit weak, behavioral principles (i.e. principles of association and imitation), it may be possible to test the appropriateness of the models experimentally. This, indeed, is suggested by Simon in concluding his article.

John W. Gyr, Ann Arbor, Mich.

347:

MATIUKHIN, N. IA. **Linear transformations of binary codes.** *Automation and Remote Control* **19,** 8 (May 1959) 759–770. (Translation of *Automatika i Telemekhanika USSR* **19,** 8 (August 1958), 776–787, by Instrument Society of America, Pittsburgh, Pa.).

(Rev. No. 4399, *Appl. Mech. Rev.* **13,** 9 (September 1960) 625)

348:

• MIDDLETON, D. **An introduction to statistical communication theory,** McGraw-Hill, 1960, 19 + 1140 pps. $25.00.

This is a remarkable book in many ways besides the size and price. The book assumes quite a background. "Moreover, little space is devoted to the probabilistic and statistical background, the elements of which the reader is assumed to possess. A knowledge of Fourier- and Laplace-transform methods, contour integration, matrices, simple integral equations, and the usual techniques of advanced calculus courses is also required, along with the elements of circuit theory and the principles of radio, radar, and other types of electronic communication systems."

In view of this, and its size, one wonders about the title, "An Introduction to Statistical Communication Theory". Indeed an examination shows that rather advanced knowledge is required to understand much that is given. It also seems fair to complain that while this amazing amount of material is quite accurately given, yet no real insights are provided; it remains an organized, but undigested, mass of material.

R. W. Hamming, Murray Hill, N. J.

MANAGERIAL APPLICATIONS

349:

• SHULTZ, GEORGE P.; AND WHISLER, THOMAS L. (Editors) **Management organization and the computer.** The Free Press, Glencoe, Ill., 1960, xvii + 259 pp. $7.50.

The contents of this book are based on a seminar sponsored by the Graduate School of Business of the University of Chicago and the McKenzie Foundation. The seminar, held at Chicago in February of 1959, brought

together a small group of experienced people for two and one half days of presentations and discussion on the title subject. The formal papers and discussion are the contents of this book. The book presents the participants' views on "information technology", defined as: (1) mathematical and statistical methods, with or without the aid of electronic computers, (2) the use of computers for mass integrated data processing, and (3) the direct application of computers to decision-making through simulation techniques. The subject is presented in four parts. The Introduction and Part 1 emphasize what this information technology makes possible. Parts 2 and 3 discuss both the technical and organizational problems involved. Part 4 presents some case histories.

Part 1 raises the question of just what things we are able to accomplish through our information technology. Problems of treating qualitative judgments too lightly and making the decision processes rigid are discussed. The implication is made that we, in fact, know precisely what the decision process is. While one of the major advantages of the information technology is said to be that of testing new ideas before making a commitment to them, it would seem necessary to distinguish among kinds of ideas, for surely this cannot be done for all ideas in the field. Part 1 defines the jobs as they will exist in the era of information technology. These jobs are those of the information technologist, the planning jobs of functional and research people, lower and middle level supervision, and top management. Some of the main problems discussed include those of "change over", personal involvements, compensation, management development, and decentralization. Basically, this portion of Part 1 contends that where operations are centralized, management must be equally centralized. It doesn't seem fair not to present the alternative argument for a multilevel system with computers at several levels and top management control at the top level. Some research required in this field is also described. This includes research in group decision-making processes, research on computers in order to facilitate these processes, organizational changes due to the information technology, research in the training of managers at Universities, and the impact on personnel practices. Also included is an interesting new slant on individual compensation and on methods of appraisal of an individual's contribution in an information technology.

Part 2 begins with material by Herbert A. Simon and Allen Newell. Their perspective is expertly stated and is based on vast research on the subject of information technology. This is the "ivory tower" of the book. The thesis here is that computers manipulate not just numbers, but any symbols. Thus, whether computers "create" or not depends upon a definition of terms, rather than on any fundamental distinction between the structure of men and machines. The discussion of how computers can create is convincing. They argue convincingly that the *results* of computer activity are essentially the same as those of human mental activity—they do not convince the reader that the means are essentially the same. The summary of this part of the book sounds a little optimistic, if not in degree, certainly in time. Simon argues that the difference in creativity between men and machines is essentially one of degree. Perhaps the degree may be so great that the essence is lost and information technology is in fact nothing like factory automation; the creativity of machines is not comparable to the creativity of people.

In the concluding portion of Part 2, Alex Orden shifts the focus from computers to "managerial systems". Actually, this section represents a useful bridge between the computer oriented portion by Simon and Newell, and the following portion on organization. Orden points out that a business organization cannot have completely defined objectives determined by its environment. He recognizes that it is not clear whether some activities can be programmed (specified precisely and sequentially) or not. Yet, he argues that the basic significance of computers to business is that they potentially "extend the range of program ability in management". And still, he does not see the computer in quite the central role as Simon and Newell do. He may even be too conservative. Orden refers to the amorphous boundaries of a major business "system". Simon's summary of the complete Part 2 is somewhat helpful, but loses some of Orden's flavor of indeterminateness and gains back the optimistic note of Simon and Newell's beginning piece.

In Part 3, Douglas McGregor expresses the view that no one—manager, worker, or society—alone reflects a true picture of an industrial organization. He stresses that automation and standardization tend to dehumanize a job, and that it is important to retain judgemental elements and the working group as a natural working unit. Under information technology, organizational roles are becoming more complex and interrelated and, hence, the difficulty of assessing the task from the organizational point of view increases. Alex Bavelas concludes Part 3 with a discussion of the psychology of communications. This discussion is rather more theoretical than the rest of the book.

Part 4 illustrates through five case histories many of the points made in the previous sections and, in addition, many other interesting points. It comprises almost one-half of the entire book. It compliments the previous sections nicely; although this reviewer would have preferred a relatively smaller emphasis on this section.

One must agree with the remark made by one of the participants to the effect that the generally enlightened views expressed in this book are unavailable from the people in the industry who are actually responsible for introducing the information technology. The fact that this is a true statement indicates that one of the main objectives of information technology must now be to spread this understanding of information technology widely enough so that it will be useful for practical implementation. Most of this book is exceptionally enlighten-

ing and well directed toward this objective. Those who are concerned with information technology, and their bosses, and their bosses, would do well to study it carefully. *John A. Postley*. Beverly Hills, Calif.

350:

Childs, J. J. **A user comments on numerical control.** *Automatic Control* **13,** 1 (June 1960), 35–39.

The article consists of a qualitative description of the experience the author has had in relatively extensive utilization of numerical machine tool control in the air frame industry, and a listing of 21 specific suggestions to manufacturers of such equipment. The chief value of the article will probably lie in the last eight of these suggestions which state specific operating features which should be included in numerical control equipment. The other suggestions are general in nature and relate to good industrial electronic design practice. In the descriptive portion of the article, much emphasis is placed on reliability and maintenance considerations. Since everyone shares the author's desire for simpler, more reliable systems, one wishes some quantitative results of their experience had been presented together with some figures on the economic justification for higher reliability.

R. G. Lex, Jr., North Wales, Pa.

351:

Madigan, J. M. **Computer controlled processing.** *Chemical Engineering Progress* **56,** 5 (May 1960).

Computer control (automation) of chemical and petroleum processes has been discussed and publicized extensively during the past two years. Most of the information published on specific processes which have been automated discusses in broad general terms the application of the computer to the process. This article continues in that vein. The author describes the application of an RW-300 digital computer to two processes at the Calvert City, Kentucky, plant of B. F. Goodrich Chemical Company. He discusses the input-output system, the computer operation, including in outline form the operation of the "executive routine", and the safe guards included in case of computer or other instrument failure. The computer has been applied to two processes, the manufacture of vinyl chloride, and the manufacture of acrylonitrile. The vinyl chloride process is under closed-loop control of the computer while only logging is being done for the acrylonitrile process. The author discusses, only briefly, the mathematical model used to simulate the process and avoids mentioning the methods used for optimization. He does mention that the b_0 constant in the multiple correlation used as part of the simulation is updated on-line, which is a first step toward adaptive control. The cost of $225,000 reported for the project includes only the charges from the computer manufacturer. It does not include any costs of Goodrich personnel. The actual cost of the project would be considerably higher. This article should be of interest to those desiring a casual knowledge of process automation, but will be of little value to persons working directly in the field.

E. L. Meadows, South Charleston, W. Va.

352:

• Hattery, L. H. **Executive control and data processing.** Anderson Kramer Associates, Washington D. C., 1959, 92 pp. $3.95.

There is no shortage of literature informing management about the benefits of electronic data processing and advising management as to appropriate courses of action. Three of the seven chapters are concerned with this type of material and though they present no new material the chapters are an excellent summary of information that is commonly available. There is an introductory chapter entitled, "Executive Functions and Management Information." The remaining three chapters deal with reports prepared for top management. This is a subject which has not been extensively treated in the past in literature dealing with electronic data processing. The appendix contains an interesting case study of a review of a reporting system. There is also a selected bibliography.

From the point of view of someone who is designing a data processing system, it would have been preferable to have the information much more technical and specific. However, Hattery prepared this book after a year of study of reporting systems in industry and intended it to be a guide to the executive in meeting the challenge of new data processing tools for more effective control. To this end the book is relatively short and emphasizes the reporting system because this is one area which is of most direct concern to management. He has succeeded in preparing a book which is easily readable by management and should provide many executives with a new insight into the reporting system. *D. Teichroew*, Stanford, Calif.

353:

McRainey, J. H. **Role of computers in automation.** *Automation* **7,** (March 1960), 48–57.

The basis for review, a complex field, scientific applications, control and administrative applications, digital and analog computers are discussed.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

354:

Heller, J. **Some numerical experiments for a flow shop and its decision-theoretical aspects.** *Operations Research* **8,** 2 (March-April 1960), 178–184.

The article contains the results of some over-simplifications in the numerical solution to scheduling simulation experiments on an IBM 704 computer. Using an M×J model, the author has concluded normal distribution from his results as opposed to asymptotically normal found in the theoretical analysis of large-scale job scheduling. He sampled different schedules in a flow shop in an effort to find a "best" schedule and, also to examine the value of random sampling in solving sequencing problems.

The presentation is good but presupposes the availability of reference material for complete explanations.

Carlis Taylor, Gainesville, Fla.

355:

Hoos, Ida Russakoff. **When the computer takes over the office.** *Harvard Business Review* **38,** 4 (July-August 1960), 102–112.

Many of us have been puzzled and disturbed by the conflicting reports of the commentators on the use of computers in commercial data processing. Some have said that computers save money; some have said they don't. Some have claimed they aid management decision; some have claimed they destroy management's prerogatives. Some have found that they upgrade jobs; others that workers are displaced and downgrade. And each viewpoint is buttressed with facts—"facts" collected mainly by interviews with managers and workers in the field. This anecdotal method suffers from many faults; perhaps the most prominent is that the researcher hears only what harmonizes with his rapidly acquired biases. However, this may explain the rather remarkable internal consistency achieved by the observers.

The article under review seems to represent another example of this anecdotal method. The author claims to have begun "a two-year study in 1957 of 19 organizations in the San Francisco Bay area that had introduced electronic data processing (EDP)." This statement is typical of the indirection which makes the work impossible to evaluate. More questions are raised than settled: (1) Was this a full time study? (2) Were all 19 organizations studied in depth? and for the full two years? (3) How were the 19 chosen? (4) How many more such companies are available for study?

Even more reprehensible than the occasional purposeful ambiguity is the repeated use of innuendo. Examples of this are the way in which the opening questions are phrased; and the attempt to discredit the European literature on automation with the label of "Marxist." Other examples of this occur in the section headings, all of which take their toll in understanding from the hurried reader. The appeal to the current wave of anti-intellectualism contained in the word "elite", twice used in headings to describe EDP people, seems out of place in what purports to be a research report. This reviewer might hasten to add that the class represented by the readers of *Computing Reviews* are not the only ones accorded this treatment.

In such comments as "It should be noted that with generalized automatic programming procedures already established in some *government* offices, and with the many new *devices* already available for programming computers with less manpower. . . ," there are unmistakable signs of a lack of knowledge of computers. (Italics are the reviewer's.) This reviewer knows of no such devices in contemporary use, except the flow charting template. In conclusion, it seems fair to say that the definitive study of the computer in the office, even for this early period, is yet to be made.

Bruse Moncreiff, Katonah, N. Y.

356:

Karp, Harry R. **Goodrich eases into computing control.** *Control Engineering* **7,** 4 (April 1960).

This paper discusses in slightly less detail than the article by J. M. Madigan (see Review No. 351) the application of an RW-300 digital computer to B. F. Goodrich's vinyl chloride and acrylonitrile plants at Calvert City, Kentucky. It contains essentially the same information included in Mr. Madigan's article

E. L. Meadows, South Charleston, W. Va.

357:

McKnight, Robert W. **Computers sharpen controls.** *Signaling and Communications* **52,** 12 (Dec. 1959), 25–32.

This article is a form of memo to railroad management. The intended message is that, after a few years of service on railroads, large and medium scale computers are beginning to do much more than the routine large volume paperwork. The more important computer functions are in the form of improved management controls and railroad operation. Although this article does not reveal any really new and startling computer application concepts, it serves well as a lucid report of what the railroads are doing now and how they look to the future for the real potential of EDP. For the most part this article consists of brief synopses of some of the more "revolutionary" railroad applications, which fall in the areas of: materials inventory and distribution, distribution and utilization of cars and equipment, simulation of train operation over centralized traffic control territory, and train performance as related to the economical assignment of motive power over a specific route. Mention is made of the burden that computer systems place on the railroads communication network. The requirement of vast amounts of information from all parts of the railroad is receiving attention from railroad communication officers. Extensive microwave systems are either in the advanced planning stage or presently under construction. As further EDP tutorial information to railroad management, this article discusses major equipment installation requirements—physical specifications, basic timetable, and a representative dollar amount. Also, emphasis is placed on how agreement has been reached between the Brotherhood of Railway Clerks and railroad officials covering persons involved in the conversion to EDP. *Marvin Howard*, Canoga Park, Calif.

358:

McRainey, J. H.; and Miller, L. D. **Numerical control.** *Automation* **7,** 8 (August 1960), 70–100.

This article relates numerical controls to the general industrial picture, describes important aspects of control systems, and points out areas where the concept has

proved successful. Historically numerical control is seen as part of the trend to obtain more efficient production through detailed planning for manufacturing. Limited-run production is considered to have benefited most from improvement in control and from the use of equipment having special distinct capabilities. Numerical control is defined as "a form of control in which automatic equipment is directly controlled by means of a portable media containing preplanned operating instructions typically in numerical form." The task of planning these operating instructions, which must be complete and accurate in every detail, is considered and their representation in different media, punch tape, magnetic tape, and punched cards is discussed and illustrated with examples. The instructions may range from the simple to those requiring the use of a computer in their preparation.

After a review of control devices, transducers, analog-type drives and power devices, and of problems of communication within the machine, control systems are considered as combinations of three basic functions. These are: Selection—which action? in what order? Controlling limits—where does the action begin? where does the action end? Continuously Synchronizing—coordinating variable rate action? continuously varying a rate with time? Each of these is discussed in turn and illustrated with examples. The article concludes with a consideration of the developments to be expected in the future. A table is included which lists future types of applications as foreseen for their equipment by individual control builders. Other tables list past applications of numerical control, some reports on results with numerical control, management problems with numerical control, and concludes with a list of companies active in the field. *Carl H. Pollmar* Ann Arbor, Mich.

359:

CHAMBERS, R. J. **Measurement and misrepresentation.** *Management Science* **6,** 2 (January 1960), 141–148.

Chambers' paper charges that traditional accounting methods misrepresent the financial results and position of modern business enterprises. The misrepresentation results from the following practices: (1) The effects of changes in monetary valuation are excluded from profit and capital cost computations; (2) Accounting transactions are timed according to the dates when legal rights and obligations are incurred, whereas some other timing basis, such as the date when cash flow occurs, or the date when value is deemed to be created, would have more economic significance; (3) The rules governing the recording of accounting transactions are not sufficiently rigid or objective; and (4) Depreciation and inventory accounting procedure is usually patterned after tax legislation.

A consequence of misrepresentation in the measurement of accounting concepts is to misdirect the flow of capital funds available for investment. Another result is to permit the introduction of biases, sometimes intentionally, which defeat the very purpose of the measurement. Mr. Chambers views the misrepresentation as a challenge to administrative science. As data processing speeds increase and computational refinements develop, a corresponding effort must be made to redefine accounting objectives, concepts and rules of procedure.

A. D. Hestenes, Detroit, Michigan

360:

CHRISTIAN, ROGER W. **Controlled plant information.** *Factory* **118,** (August 1960), 60–81.

The author points out that the key to obtaining better information for the control of manufacturing plant is good data processing systems analysis and systems design. Generally computers will be needed to implement these systems although sometimes they can be implemented with less powerful equipment. Management in general has not recognized the importance or significance of data processing upon profit performance. But to recognize the importance and then to do something about it management must take into account: (1) the character of the equipment (some brief description is provided); (2) some human problems (some are listed); and (3) some factors of systems analysis and design (only a brief discussion given). A few suggestive applications are listed: American Machine and Foundry—Shop Loading and Operating Efficiency; Lawrence Manufacturing Company—Defect Analysis Reports; Freeman Shoe Corporation—Production Records; Westinghouse Electric Corporation—Inventory Control; General Electric Automatic Blanket and Fan Department—Labor Cost and Payroll; Jackson Mills—Maintenance Work.

Ned Chapin, Menlo Park, Calif.

361:

BORKLUND, BILL. **How we mismanage the mechanical moron.** *Armed Forces Management* **6** (July 1960), 22–23, 66.

The use of computers in the Department of Defense establishments has actually increased demands made upon management, not decreased them. The failures to rise to these increased challenges has served to highlight several weaknesses in the uses of computers in the Department of Defense. The major ones of these are: the continuation of manual procedures after they should have been abandoned; the preparation of useless reports, and of more reports than needed; the lack of coordination and lack of profiting from experience; the trend to "keep up with the Joneses" in the use of computers; the consistent underestimate of programming and peripheral equipment costs, and the consistent overestimate of savings; and the low quality of input information.

Ned Chapin, Menlo Park, Calif.

362:

HAMLIN, FRED. **Why frustration at Fort Meade?** *Armed Forces Management* **6** (July 1960), 27–28, 33.

At Fort Meade in Maryland, the U. S. Army since 1956 has been attempting the use of a UNIVAC File Computer for a combination of individually low volume applications. Judging from what is said in this article the frustration was caused in no small part by inadequate systems analysis and weak management support.

Ned Chapin, Menlo Park, Calif.

363:

Production data system improves management Control. *Automation* 7 (June 1960), 80–81.

The Norair Division of Northrup Corporation has developed a production reporting system using some 100 Friden Collectadatas and an IBM 704. The savings from the use of this installation have been primarily in the area of man hours by shopworkers and foremen and from the elimination of reports.

Ned Chapin Menlo Park, Calif.

364:

DREIMAN, ROY N. **What a utility has learned with EDP.** *The Controller* **28** (August 1960), 362–365.

Pacific Gas and Electric Company in San Francisco has used one IBM 705 for revenue accounting since 1957 and two since 1959. Approximately two and a half years of time and 40 man-years were spent in the preparation of the revenue accounting application. Once the conversion of that application was nearly complete, other applications of much smaller size were added including some engineering applications.

Ned Chapin, Menlo Park, Calif.

365:

BORKLUND, BILL. **EDP: Trouble at the top.** *Armed Forces Management* **6** (July 1960), 9.

Computers have the power of multiplying management's failures as well as its successes. In the Department of Defense of the U. S. Government, some of the failures are properly attributable to the normal mistakes involved in pioneering with computers, but others clearly appear to be in the category of management failures.

Ned Chapin, Menlo Park, Calif.

MECHANICAL LANGUAGE TRANSLATION

366:

HUBBELL, A. F.; BAKST, AARON; ARTIN, NATASHA; AND SHUFF, SUSAN. **Russian-English scientific and technical dictionaries; a survey.** *National Science Foundation Report*, 1960.

A bibliography of Russian-English dictionaries, multilingual dictionaries usable as Russian-English ones and English-Russian dictionaries with Russian-English sections. Reviews of each are given from the point of view of needs in particular fields.

E. W. King, Yorktown Heights, N. Y.

NON-NUMERIC APPLICATIONS

367:

BEDA, L. M.; KOROLEV, L. N.; SUKHIKH, N. V.; AND FROLOVA, T. S. **Programs for automatic differentiation for the machine BESM.** Institute for Precise Mechanics and Computation Techniques, Academy of Sciences, USSR, Moscow, 1959, 19 pp.

This program makes use of the basic three-address decomposition described by Ershov and others to develop derivatives of analytical algebraic expression made up of the ordinary arithmetic functions, exponentiation, square and cube root, trigometric and inverse trigonometrix functions, logarithm, and hyberbolic functions. By working strictly with the three-address (Polish-Prefix) decomposition and keeping tables of both the original expression and the derivatives of the elements of the decomposition in this form, it appears that an apparent programming simplification is obtained. No link-list appears to be used, and symbols are input in an integer code, apparently. Examples of problems worked with this BESM program are given, as well as a detailed, natural language description of the parts of the program.

John W. Carr III, Chapel Hill, N. C.

368:

PAINTER, JAMES A. **Computer preparation of a poetry concordance.** *Comm. ACM* **3,** 3 (February 1960), 91–95.

The paper describes the preparation of a concordance of the collected poems of Matthew Arnold by means of an IBM 704. The concordance has been published by Cornell University Press as the first of a series of mechanically prepared concordances. Although the results will, as the author states, clearly be better when improved type facilities for the machine output are available, this is clearly the way in which concordances ought to be made. While the so-called "common words" are obviously out of place in a published concordance and are therefore excluded by the author from his sorting, should someone prepare a concordance of a large text and produce as a separate output the part relating to common words, a very useful service to language study would be done. In an important sense, for language or Machine Translation research, it is the common words about which we know the least, and need to know the most.

Roger M. Needham, Cambridgeshire, England

369:

WANG, HAO. **Proving theorems by pattern recognition I.** *Comm. ACM* **3,** 4 (April 1960), 220–234.

This paper is an extension of the author's "Toward a Mechanical Mathematics" (*IBM J. Res. Develop.*, **4,** (1960), 2–22), and the two papers should be read (and are here reviewed) together. The papers contain: a proposal for a new branch of logic, *inferential analysis*, which stands to mechanical proof as numerical analysis does to

ordinary arithmetic calculation; descriptions of several schemes for proving theorems, thus illustrating inferential analysis; comparisons with "heuristic methods"; a wide variety of philosophical observations about logic, mathematics, digital computers, and the intersections thereof. All told, this material together with Part II of the present paper (to be published separately) would make a substantial monograph.

There are three ways of proving theorems on digital computers: by using (1) decision procedures, (2) proof procedures, or (3) "heuristic" procedures.

(1) When there is an algorithm for deciding whether any well-formed formula of a formal system is a theorem or not, the system has a *decision procedure*. The propositional calculus and singulary predicate calculus, as well as certain formalizations of elementary algebra, geometry, group theory, etc. have decision procedures. A decision of procedure does not necessarily produce a proof in the usual sense, but only a Yes or No answer.

(2) If a formula of a system is a theorem, a proof can always be found mechanically, even lacking a decision procedure, since a proof is a finite sequence of finite length formulas. Hence, there is always a partial algorithm or *proof procedure* for theorem-hood in the sense that, if a formula is a theorem, the algorithm will produce a Yes (and maybe a proof also), but if it is not, the calculation may never terminate. The proof procedure problem is one of efficiency, not existence.

(3) A *heuristic procedure*, as the reviewer understands the term, consists of quasi-algorithms which may never terminate and which are imitative of human intuitional methods, thus consisting of scanning for similarities and of "inferential leaps".

Wang's papers report proof procedures based on an axiom-free Gentzen type formalism for the predicate calculus with equality, which are also decision procedures for the known decidable sub-domains including, of course, the propositional calculus. His program turns out the theorems in the propositional calculus of *Principia Mathematica* in about three minutes proof time (excluding input-output). The extended program of the title paper can do nine chapters of the *Principia* (350 theorems) in 8.4 minutes with full print out of proofs. Since most mathematics is expressible in the predicate calculus, Wang argues persuasively that his studies or similar ones based on a solid use of logical theory are necessary preliminaries to doing mechanical mathematics on a larger scale. The "heuristic procedures" of Newell and Simon (which do not come close to Wang's achievements with respect to proving power) do not employ any of the theory developed by logicians over the last half century. Wang suggests that alternative methods (neither decision nor proof procedures) may give quick though not necessarily correct answers, and are useful when validated by checking algorithms. Indeed his own pattern recognition methods contain such elements. However "... the mysterious elements of creative activity seem likely to be replaced by a complex web of clearly understood, definite, and deterministic algorithms, rather than random elements or obscure machine programs." (p. 233 f.)

The reviewer would advocate an attitude of tolerance toward all responsible approaches to mechanical mathematics but with the recommendation that psychological investigation (thought simulation, for example) and inferential analysis be distinguished. Information processing theory will not necessarily benefit any more from psychology than mechanical engineering does from physiology.

R. J. Nelson, Cleveland, Ohio

NUMERICAL MATHEMATICS

370:

THACHER, HENRY C., JR.; AND MILNE, W. E. **Interpolation in several variables.** *J. Soc. Indust. Appl. Math.* **8,** 1 (March 1960), 33–42.

Three variations of the fundamental formula for interpolation in several independent variables are given. The third procedure generalizes to several variables the method of Aitken. All three procedures are applied to a numerical example. The first variation is especially suitable to the case where several functions must be interpolated at several different points using the same set of base points. One matrix inversion is required; a matrix-by-vector multiplication must be performed for each function and a vector inner product must be computed for each interpolation. For the second method, a constant must be included among the basis functions. In this case, the evaluation of two determinants for each interpolation is required. The third formula is limited to polynomial interpolation. It is an iterative algorithm which produces results of successively higher degree by repeated application of a single relatively simple procedure. For a function in s variables basis polynomials are selected which yield a unique interpolative polynomial of degree n that agrees with the function at the base points. The minimum number of base points required is $(n+s)!/n!s!$. A sufficient set of criteria is given for choosing the base points to be used for performing each interpolation of lower degree.

Nancy M. Dismuke, Oak Ridge, Tenn.

371:

ROE, GLENN M. **An accurate method for terminating asymptotic series.** *J. Soc. Indust. Appl. Math.* **8,** 2 (June 1960), 354–367.

Series asymptotic in the Poincaré sense are sometimes inadequate numerically because the remainder term after summing to a finite number n of terms does not tend to zero, but has a finite minimum modulus, which occurs for a finite n. Often this minimum modulus is too big for the computational accuracy desired. Many devices have been used to overcome this difficulty and to attain higher precision. The problem of obtaining this higher precision can be subdivided thus:

(i) Since the series diverges, we must *define* its "sum" in some way that is mathematically useful.

(ii) We must then manipulate this "sum" in such a way that greater numerical precision is attainable. This is usually by re-expansion of a remainder term.

(iii) We must then find the precise mathematical connection between the "sum" we have defined, and the function for which the asymptotic expansion was developed. Alternatively we may prove *consistency theorems* connecting with other definitions of "sums" for the same series, in the hope that one of these is properly identified with the given original function.

(iv) Finally we should investigate the nature of the re-expansion or other process devised in (ii) to estimate a new limit to precision.

Step (i) is always implicit in any proposed method, though this is sometimes not appreciated by the author concerned. Stieltjes (1866) gives the first example known to me. This is, as we might expect, thoroughly comprehensive; he re-expands a known remainder term, thus combining steps (i) and (ii), and he considers (iv). The somewhat empirical methods of Airey (1937) combine steps (i) and (ii) without investigating (iii) and (iv). He complains of "neglect" by others of certain terms in the asymptotic expansions of certain Bessel Functions (the Kelvin functions), without realising that *both* series are correct in the Poincaré sense, but that he has not himself carried out step (iii) and so the misidentification is only brought to light by numerical examples.

We must mention here the paper of Watson (1911) which brilliantly carries out steps (i) and (iii) for Borel Summation, a definition with wide application; the limitations are clearly stated as we would expect.

Miller (1952) defines the remainder in terms of a differential equation and a difference equation, and completes the identification in (iii) numerically by means of complementary functions. There is no attempt at step (iv). Step (iv) has been considered in some special cases, e.g. see Rosser (1955). Dingle (1958), etc. adopts the Borel sum, and so his justification can be based on Watson (1911). He covers all stages except (iv).

The paper now reviewed, by G. M. Roe, adopts a definition for the "sum" that results in a contour integral. The path of the integral is then deformed to produce several terms in the original asymptotic expansion, together with a remainder term, which he re-expands in a novel way (without however considering (iv)). His identification process (iii) is numerical. Roe's paper is concerned with asymptotic series of "the second kind", that is, having all terms ultimately positive. This is a more difficult case than the one where terms untimately alternate in sign. His method is satisfactory for numerical use though not, in my view, quite comparable in ease of use (as he claims) with the Euler transformation for series of alternating signs. All methods or definitions proposed have some limitation in the type of series to which they are applicable. If the series is formally

$$\sum_0^\infty \frac{A(n)}{x^n},$$

or

$$\sum_0^N \frac{A(n)}{x^n} + R(n, x),$$

then we can describe the limitations thus:

Stieltjes' limitation is the development or known existence of an exact remainder term $R(n, x)$ which he expands.

Airey's limitation was implicit in his manipulation of $\sum_N^\infty (A(m)/x^n)$; it usually meant that a simple expression involving factorials was known for $A(n)$.

Watson's definition applies only under stated limits to the rates of variation of $A_n(n)$ and $R(n, x)$ as n and $x \to \infty$.

Miller's method applies only if both differential and difference equations can be found for $R(n, x)$.

Dingle's method depends on Watson's "sum" and has similar limitations. Roe's limitation is the assumed existence of $A(z)$, an analytic function equal to $A(n)$ for every $z = n$, and the possibility of the processes he applies to it. (Presumably this holds only for $z = n \geqq 0$, though Roe does not state this.) This new method for estimating the "sum" of an asymptotic series seems a useful extra tool, on a par with several others. Like most of these, it still requires further mathematical investigation.

References:

J. R. Airey, 1937. The converging factor in asymptotic series and the calculation of Bessel, Laguerre, and other functions. *Phil. Mag.* {7}, **24**, pp. 521–552.

J. C. P. Miller, 1952. A method for the determi nation of converging factors, applied to the asymptotic expansions for the parabolic cylinder functions. *Proc. Cambridge Philos. Soc.* **48**, pp. 243–254.

R. B. Dingle, 1958, 1959. Asymptotic expansions and converging factors. *Proc. Roy. Soc. London*{*A*} **244**, pp. 456–490, {A} **249**, pp. 270–295.

J. B. Rosser. 1955. Explicit remainder terms for some symptotic series. *J. Rational Mech. Analysis* **4**, No. 4, pp. 595–626.

T. J. Stieltjes, 1866. Recherches sur quelques series semi-convergentes. *Ann. Sci. de l'École Normale Superieure* {3}, **3**, pp. 201–258.

G. N. Watson, 1911. A theory of asymptotic series. *Philos. Trans. Roy. Soc.* {A} **211**, pp. 279–313.

J. C. P. Miller, Cambridge, England

372:

Anderson, W. H. **The solution of simultaneous ordinary differential equations using a general purpose digital computer.** *Comm. ACM* **3,** 6 (June 1960), 355–360.

The present paper gives a discussion of the allocation of memory storage for the numerical solution of a system of ordinary differential equations. Special consideration is given to the problem of optimizing the interval length with respect to truncation errors and machine time. Other authors have considered the same problem much along the same lines. The Runge-Kutta fourth order method is discussed in detail and an explicit formula is given for the optimum interval length. However, Gill's variant, which seems to be the most common one in practice, is not mentioned. A flow diagram of the process is also presented. *Carl-Erik Fröberg*, Lund, Sweden

373:

CHIROL, HENRI. **Dispositifs pratiques facilitant l'analyse et la synthèse harmonique** (Practical procedures aiding harmonic analysis and synthesis). *Chiffres* **2**, 4 (December 1959), 219–231. (French)

Approximate Fourier coefficients, usually employed in harmonical analysis, can be replaced with advantage by approximate harmonics themselves. *Author's Abstract*

374:

• FADDEEVA, V. N. **Computational methods of linear algebra.** Dover Publications, Inc., New York, 1959, x + 252 pp. $1.95.

This is a translation of an excellent book in Russian. Its three chapters cover respectively: Basic material from linear algebra, systems of linear equations, and the proper numbers and proper vectors of a matrix. The author not only gives well-chosen numerical examples to illustrate the various methods and ideas, but also whole sections comparing various methods. The book is a significant contribution to the field of numerical computation.

Richard W. Hamming, Stanford, Calif.

375:

KREISS, HEINZ-OTTO. **Über die Differenzapproximation hoher genauigkeit bei Anfangswertproblemen für partielle Differentialgleichungen** (On higher-precision difference approximation for initial value problems in partial difference equations). *Numerische Math.* **1**, 4 (September 1959), 186–202. (German)

Stability of finite difference approximations to a broad class of mth order systems of linear partial differential equations of the form

$$\text{(i)}\quad u_t - P(x, t, \partial/\partial x)u = F(x, t), \quad u(x, 0) = f(x)$$

is considered where x is a vector in R^s and $u(x, t)$ is an n-vector. Let

$$\text{(ii)}\quad \begin{aligned} u(x, t+k, k) &= (1 + \lambda Q(x,t,k))u(x,t,k) + kG(x,t) \\ u(x,0,k) &= f(x) \end{aligned}$$

be a system of finite difference equations which approximates (i) in the sense that

$$k^{-1}(v(x,t+k) - v(x,t)) - k^{-1}Qv - v_t + Pv + G - F = O(k^\alpha)$$

for $v \in C^m$ and $0 < \alpha < \infty$. Sufficient conditions involving P, F, Q, G, λ are given such that (ii) has stable solutions for large α.

Particular cases in which stability is proved are:

(iii) Hermitian systems in which $F = G = 0$, P has the form $P = \sum A_n(x,t)\partial/\partial x_n$ where A_n is a Hermitian matrix, $Qu = \sum Q_j u(x,t-jk,k)$ where Q_j is of odd degree in $P(x,t-jk,\Delta)$, and $P(x,t,jk,\Delta)$ is a polynomial of odd degree in the difference operators $\Delta_j(2h)$ with coefficients Hermitian entire rational functions of A_n;

(iv) parabolic systems in which $P(x,t,\partial/\partial x)$ is a strongly negative elliptic operator of order $2m$, $F = G = 0$, and Q is an explicitly given difference operator approximating P.

The results (iii), (iv) are shown to apply to a number of specific difference systems obtained using Adams' extrapolation and interpolation formulas. Examples of unstable difference systems are given. The work extends results of the same author for the case $0 < \alpha < 1$.

The exposition is clear, complete, and the notation is well adapted to the subject matter and the proofs.

John B. Butler, Jr., Tucson, Arizona

376:

NIEDHOFER, GERHARD. **Intégration approachée des équations différentielles lorsque la dérivée d'ordre le plus élevé ne figure que dans un terme correctif** (Approximate integration of differential equations when the highest derivative occurs only in a corrective term). *Chiffres* **2**, 1 (March 1959), 43–53. (French)

If in a linear and homogeneous equation $F(y, y', y''; x) = 0$ the coefficient of y'' is much smaller than the coefficients of the other terms, it is considered as a correction term and its suppression determines a solution of the first degree equation. On the basis of this solution a further approximation of the complete equation is calculated. The author applies this method to the case of a linear equation with constant coefficients and to some simple examples with variable coefficients. In the last mentioned cases the series of approximated solutions are not convergent. *Manuel Sadosky*, Buenos Aires, Argentina

377:

ESCH, ROBIN E. **A necessary and sufficient condition for stability of partial difference equation problems.** *J. A. C. M.* **7**, 2 (April 1960), 163–175.

Numerical methods for solving partial differential equation problems show, under certain conditions, a very disturbing phenomenon of instability, that is, blowing up of the approximate solutions when the time interval $\Delta t \to 0$. Richtmyer [*Difference Methods for Initial-Value Problems*, Interscience, New York, 1957, 238 pp., $7.25] formulates several conditions for the stability. This paper gives a simpler condition which is both necessary and sufficient and which includes Richtmyer's conditions as special cases.

If the solution of the approximating difference equation is expanded in a Fourier series in space coordinates, and if the Fourier coefficients $A^n(k)$ at the nth time point can be expressed in the form

$$A^n(k) = [G(\Delta t,k)]^n A^0(k),$$

then the necessary and sufficient condition for stability is the following:

In the limit as $n \to \infty$, $0 \leqq n\Delta t \leqq T$, *each eigenvalue* $\lambda = \lambda(k,\Delta t)$ *of* G *must have magnitude such that* $n^{p-1}\lambda^n$

is bounded, where p is the size of the Jordan box in which λ *appears. This must hold uniformly over all k.*

An interesting example of the wave equation is added to illustrate the application of the theorem.

Sigerti Moriguti, New York, N. Y.

378:

CESCHINO, FRANCIS. **Sur une formule de Runge-Kutta de range cinq** (On a fifth order Runge-Kutta formula). *Chiffres* **2,** 1 (March 1959), 39–42. (French)

It is known that the names of Runge, Kutta and others, are associated with methods of finding numerical solutions of the problem $y' = Y(t,y)$ by replacing a truncated Taylor series expansion of y by an approximation in which the value of the function is repeatedly evaluated in a certain interval. This is convenient and easy to program.

Çeschino, Kuntzmann and Zurmuhl have made some inroads into the problem of solving

$$y^{(p)} = Y(t,y,y', \cdots ,y^{(p-1)})$$

by a similar method, without going through the usual first-order equivalent system, and in this brief paper the general formulas are stated and one set of coefficients for the case $y'' = Y(t,y,y')$ are given explicitly. Whether they may prove useful in numerical computation on present day computers remains to be seen, but it certainly is a fine subject to investigate.

Fernán Rodríguez-Gil, Caracas, Venezuela

379:

STEWART, CHARLES E. **On the numerical evaluation of singular integrals of Cauchy type.** *J. Soc. Indust. Appl. Math.* **8,** 2 (June 1960), 342–353.

The author develops a convergent sequence of approximations to Cauchy integrals of the form

$$\int_a^b \frac{f(x)\,dx}{(x-y)(b-x)^{1/2}(x-a)^{1/2}} \qquad a < y < b \quad \text{(C)}$$

This is done by using a sequence $\{p_n(x)\}$ of polygonal (i.e. piecewise linear) approximations to f whose secants, $P_n(x,y) = [p_n(x) - p_n(y)]/(x - y)$, converge uniformly in the region $a \leqq x \leqq b$, $a \leqq y \leqq b$, $x \neq y$. The author proves that the sequence of integrals formed by replacing $f(x)$ in (C) by $p_n(x)$ converges uniformly on (a, b) and thereby obtains the approximations to (C). Using this sequence of approximations a sequence of approximations to the second order Cauchy integrals is also obtained. The main results are preceded by a discussion of Hölder functions which are used in the proofs. No error analysis is attempted and no numerical results are presented.

Anthony Ralston, New York, N. Y.

380:

● GANTMACHER, F. R. **Applications of the theory of matrices.** Interscience Publishers, New York, 1959, ix + 317 pp., 24 cm. $9.00.

(Rev. 43, *Math. Comput.* 14, 71 (July 1960), 284)

381:

BLAIR, K. W.; AND LOUD, W. S. **Periodic solutions of x'' + cx' g(x) = Ef(t) under variation of certain parameters.** *J. Soc. Indust. Appl. Math.* **8,** 1 (March 1960), 74–101.

The authors consider the existence, appearance and disappearance of periodic solutions of the equation $x'' + cx' + g(x) = Ef(t)$ as the parameters c and E vary. This equation occurs in applications such as the study of vibrations of forced nonlinear systems and the study of nonlinear electrical circuits containing a saturable-core inductance. The paper contains the following sections:

1. *Introduction.* The concept is introduced of a phase plane with coordinates x and $y = x'$. A fixed point is defined as a point in the phase plane which maps (i.e. as dictated by the equation) into itself after a period of time T. Convergence to a fixed point is discussed and the notion of a domain of attraction is introduced.
2. *Periodic solution of the equation for small E.*
3. *A theorem on movement of fixed points*
4. *A theorem on domains of attraction*
5. *An approximate technique for locating fixed points*
6. *Experimental results.* The approximate technique of section 5 is evaluated empirically using a Univac Scientific Computer. The computations principally involved numerical integration for which the Runge-Kutta-Gill method was used. A sinusoid forcing term was used of $f(t) = \cos t$ and two cases of nonlinear $g(x)$ were considered (corresponding to hardening and softening of the effective spring constant with amplitude). Results are presented in both graphical and tabular form.

F. J. Corbato, Cambridge, Mass.

382:

SCHEFFLER, D.; AND ONDREJKA, R. **The numerical evaluation of the eighteenth perfect number.** *Math. Comput.* **14,** 70 (April 1960), 199–200.

This paper gives the decimal representation of the perfect number $2^{3216}(2^{3217} - 1)$ which corresponds to the 18th Mersenne prime. An IBM 709 was used for the computation.

R. Wonderly, Chapel Hill, N. C.

383:

LAASONEN, PENTTI. **A Ritz method for simultaneous determination of several eigenvalues and eigenvectors of a big matrix.** *Ann. Acad. Sci. Fenn.* {A} I, 265 (1959), 16 pp.

An integer $m < n$ is said to be "normal" with respect to an $(n \times n)$ matrix A, if there are m eigenvalues of A greater in absolute value than the $n - m$ others. Let Y and V be two $(n \times m)$ matrices of rank m, for each of which the leading $(m \times m)$ submatrix is nonsingular. Let

$$Y^{(k)} = A^k Y, \quad V^{(k)} = A'^k V, \quad Q^{(i+j)} = V^{(i)\prime} Y^{(j)}.$$

If m is normal with respect to A, the author proves that

the roots of $\det(Q^{(k+1)} - \mu Q^{(k)}) = 0$ converge (as $k \to \infty$) to the m dominant eigenvalues of A. The direction of the convergence is studied for Hermitian matrices, when $V = \bar{Y}$. The author concludes from a perturbation analysis that his method is essentially comparable in regard to round-off error with related biorthogonalization methods of F. L. Bauer [*J. Assoc. Comp. Mach.* **5** (1958), 246–257].

G. E. Forsythe, Stanford, Calif.

Courtesy, *Math. Reviews*

384:

SELECTED TITLES FROM *Applied Mechanics Reviews:*

HERFURTH, G. **The maximum propagated error.** *Technik* **14**, 8 (August 1959), 536–537. (German)
(Rev. No. 4393, *Appl. Mech. Rev.* **13**, 9 (September 1960) 625)

LAUCHLI, P. **Iterative solution and error estimate in approximation methods.** *ZAMP* **10**, 3 (May 1959) 245–280. (German)
(Rev. No. 4394, *Appl. Mech. Rev.* **13**, 9 (September 1960) 625)

RUTISHAUSER, H. **On the Gauss-Jordan method of matrix inversion.** *ZAMP* **10**, 3 (May 1959) 281–291. (German)
(Rev. No. 4395, *Appl. Mech. Rev.* **13**, 9 (September 1960) 625)

CLERC, D. **Study of dominant and subdominant proper values (eigenvalues) of a real or complex matrix.** *ONERA* Pub. 72 (September/October 1959) 53–58. (French)
(Rev. No. 4396, *Appl. Mech. Rev.* **13**, 9 (September 1960) 625)

SZIDAROBSZKY, J. **Practical method for solving differential equations with nonconstant coefficients.** *Acta Techn. Acad. Sci. Hungaricae, Budapest* **24**, ½ (1959), 85–94. (German)
(Rev. No. 4397, *Appl. Mech. Rev.* **13**, 9 (September 1960) 625)

BORWEIN, D.; AND MITCHELL, A. R. **The effect of boundary conditions and mesh size on the accuracy of finite difference solutions of two-point boundary problems.** *ZAMP* **10**, 3 (May 1959), 221–232.
(Rev. No. 4398, *Appl. Mech. Rev.* **13**, 9 (September 1960) 625)

OSTROWSKI, A. M. **On the convergence of the Rayleigh quotient iteration for the computation of the characteristic roots and vectors. Parts 3 and 4: Generalized Rayleigh quotient and characteristic roots with linear elementary divisors; Generalized Rayleigh quotient for nonlinear elementary divisors.** *Arch. Rational Mech. Anal.* **3**, 4, (Aug. 1959) 325–347 (English)
(Rev. No. 3228, *Appl. Mech. Rev.* **12**, 7 (July 1960) 467)

TAKEYAMA, H. **Expressions for interpolation and numerical integration of high accuracy.** *Technol. Rep. Tohoku Univ.* **23**, 1, 1958, 47–70.
(Rev. No. 3229, *Appl. Mech. Rev.* **13**, 7 (July 1960) 467)

385:

RIVLIN, T. J. **A note on smooth interpolation.** *SIAM Review* **2**, (January 1960), 27–30.

In a previous paper (*SIAM Review*, **1**, 60–63) a method was suggested for interpolation by polynomials of increasing degree which minimized oscillation and which we called "smooth interpolation." In this paper it is proved that this process converges to straight-line interpolation.

Courtesy *IBM J. Res. Develop.* **4**, 3 (July 1960)

386:

• GUPTA, H.; CHEEMA, M. S.; MEHTA, A.; AND GUPTA, O. P. **Representations of primes by quadratic forms, Part I.** Roy. Soc. Math. Tables Vol. 5, Cambridge Univ. Press, 1960, 24 + 135 pp. $8.50.

The quadratic forms considered in the present volume are $a^2 + Db^2$, $D = 5, 6, 10, 13$, and the primes considered are those less than 100000. Only one quarter of all primes can be represented by any one of these quadratic forms. They consist in those primes that are in the following arithmetic progressions:

For D = 5,	p = 20m + 1, 9
For D = 6,	p = 24m + 1, 7
For D = 10,	p = 40m + 1, 9, 11, 19
For D = 13,	p = 52m + 1, 9, 17, 25, 29, 49

For each of these primes <100000, the left-hand pages of the table give a, b, k, n in the equations, $p = a^2 + Db^2$, $kp = n^2 + D$. Another quarter of the primes are such that their doubles can be so represented. They are the primes in the following arithmetic progressions:

For D = 5,	p = 20m + 3, 7
For D = 6,	p = 24m + 5, 11
For D = 10,	p = 40m + 7, 13, 23, 37
For D = 13,	p = 52m + 7, 11, 15, 19, 31, 47

For each of these primes <100000, the right-hand pages give a, b, k, n in the equations

$$2p = a^2 + Db^2, \quad 2kp = n^2 + D$$

The remaining half of the primes cannot divide any number of the form $a^2 + Dq^2$.

The values were produced by hand calculation using two movable strips of paper to obtain a and b. The value of n, from which k is easily obtained, is given by

$$n = | ax + Dby |$$

where $ay - bx = 1$.

The tables are photolithed from copy prepared on a card-controlled typewriter. Hence the hand-prepared data was punched on cards. Each card was checked by running it through a Hollerith Multiplying Punch; so the tables should be exact. Great care was taken to assure the inclusion of every relevant prime p. The tables are intended to be of use to number theorists, especially those interested in the special quadratic fields $K(\sqrt{-D})$ for the values of D considered. In particular, the representations $p = a^2 + 5b$ are useful in the problem of small quintic residues. There is a good introduction to the theory of ideals in quadratic fields but no applications are considered.

D. H. Lehmer, Berkeley, Calif.

387:

HASELGROVE, C. B.; AND MILLER, J. C. P. **Tables of the Riemann Zeta function.** Roy. Soc. Math. Tables, Vol. 6, Cambridge University Press, 1960, 23 + 80 pp., $9.50.

These tables represent the systematic effort to tabulate

the Riemann zeta function

$$\zeta(s) = 1 + \frac{1}{2s} + \frac{1}{3s} + \cdots$$

in the complex plane. Despite its simple definition and the fact that its only singularity is its familiar simple pole at $s = 1$, this function is very hard to compute, and so any extensive tables of its values have had to wait for the electronic digital computer. Even with this powerful tool, elaborate asymptotic formulas and double precision are needed to obtain 6-decimal accuracy. The tables refer to values of $\zeta(\frac{1}{2} + it)$ and $\zeta(1 + \text{it})$, $(t > 0)$, so that only two vertical lines of the complex plane are treated. Of course, the line $\frac{1}{2} + it$ is the most interesting one of all, for on this "critical line" the complex zeros of $\zeta(s)$ seem to lie. The original code for the Cambridge EDSAC was written for the critical line but it was found that the line $1 + it$ could be treated with relatively minor alterations. Most of the results were recalculated on the Manchester University Mark I.

There are two main tables. Table I gives the real and imaginary parts of $\zeta(\frac{1}{2} + it)$ and $\zeta(1 + it)$ for $t = 0(.1)100$ to 6D. In addition, the continuous real values functions $Z(t)$ and $\theta(t)$ in the relation

$$\zeta(\tfrac{1}{2} + it) = Z(t) \exp\{-\pi i\theta(t)\}$$

are tabulated. Table II gives only the "signed modulus" $Z(t)$ for $t = 100(.1)1000$.

Table III gives γ_n for the first 1600 zeros $\frac{1}{2} + i\gamma_n$ of $\zeta(s) = 0$ together with the corresponding values of $|\zeta'(\frac{1}{2} + i\gamma_n)|$. For the first 650 zeroes, there is additional information, namely, $1/\pi \arg \zeta'(\frac{1}{2} + i\gamma_n)$ and the so-called Gram point g_n which is the solution of the transcendental equation

$$\arg\{\pi^{-t/2}\Gamma(\tfrac{1}{4} + \tfrac{1}{2}it)\} = n\pi$$

Table IV tabulates $Z(t)$ and its zeros for four special ranges near $t = 7000$, 17000, 100000, and 250000. The first two ranges confirm the discovery by the reviewer of two near failures of the Riemann Hypothesis. The other two ranges give pictures of the function a great distance up the critical line.

The last table, Table V, gives 6D values of

$$(1/\pi) \arg \Gamma(\tfrac{1}{2} + it)$$

for $t = 0(.1)50(1)600(2)1000$.

Section 6 of the introduction gives an elaboration of the Riemann-Siegel formula for $Z(t)$ and $\zeta(1 + it)$ and tables of coefficients in this expansion. A mere glance at these formulas gives a pretty clear picture of the difficulties in tabulating $\zeta(s)$.

The tables have already been useful in Haselgrove's disproof of the Polyà conjecture that for $x \geqq 2$ at most half of the numbers $\leqq x$ have an even number of prime factors. Many exact formulas for numerical functions can be expanded items of the zeros of $\zeta(s)$. These now become useful formulas rather than curiosities, thanks to the publication of these tables.

D. H. Lehmer, Berkeley, Calif.

388:

● BURUNOVA, N. M. **Spravochnik po matematicheskim tablicam, Dopolnenie No. 1** (Reference book on mathematical tables. Supplement No. 1.). Akademiya Nauk SSSR. Vychislitel'nyĭ Centr. Izdat. Akad. Nauk SSSR, Moscow, 1959, xxxix + 183 pp. 9 rubles.

This is a welcome supplement to Lebedev and Fedorova's bibliography of mathematical tables [Spravochnik po matematicheskim tablicam, Izdat. Akad. Nauk SSSR, Moscow, 1956, 552 pp.; MR 18, 828—see the review for background]. Whereas LF [Lebedev and Fedorova] cover tables available up to about 1954, B [Burunova] claims to extend the coverage to material contained in certain Soviet libraries or reviewed in the world's principal abstracting journals before approximately the middle of 1958. The publication dates for tables cited in B actually range from 1942 to 1959, but most are from 1951 to 1956.

The format of Burunova follows LF exactly. B's outline of functions is less complete than LF's in that B includes only titles not in LF. However, B includes a table of contents to the outline of functions in both LF and B, with page numbers for LF and B in parallel columns. The functions listed in B but not in LF are: logarithms to base 2, confluent hypergeometric functions, the Riemann-zeta function, biharmonic polynomials, Weber functions, and functions related to light-scattering. On page 180 of the index, a block of author names is out of order.

G. E. Forsythe, Stanford, Calif.

Courtesy *Math. Reviews*

389:

KIRKPATRICK, E. T. **Tables of values of the modified mathieu functions.** *Math. Comput.* **14,** 70 (April 1960), 118–129.

The functions tabulated, in the well-known notation of Goldstein, Ince and McLachlan (see McLachlan 1947, *Theory and Application of Mathieu Functions*, London, Oxford Univ. Press) are

$$Ce_n(u,q), \quad n=0(1)5; \qquad Se_n(u,q), \quad n = 1(1)6,$$

these being solutions of the modified Mathieu equation

$$\frac{d^2y}{du^2} - (a - 2q \cosh 2u)y = 0.$$

Values are given to 5 decimals, or to 5 or 6 figures, for

$$q = 1(1)10(2), \qquad u = .1(.1)1.$$

There is a list of defining formulas and a short description of the computations.

J. C. P. Miller, Cambridge, England

SCIENTIFIC AND ENGINEERING APPLICATIONS

390:

● BIRKHOFF, G.; AND LANGER, R. E. (Editors). **Proceedings of symposia in applied mathematics, Vol.**

IX: **Orbit theory.** American Mathematical Society, 1959, v + 195 pp. $7.20 (25% off for AMS members).

The ten papers reproduced here were presented at an AMS symposium held in April 1957. At least four of these have been published elsewhere, essentially unchanged, prior to appearance of the book under review. Three of the four have been printed earlier undoubtedly because of the long delay between presentation in early 1957 and publication in late 1959. It is a sad commentary that so important a set of articles should be so long in printing. The four which the reviewer recalled from earlier reading are "Störmer Orbits" by W. H. Bennett, "General Theory of Oblateness Perturbations" by P. Herget, "Cislunar Orbits" by K. A. Ehricke, and "Satellite Launching Vehicle Trajectories" by J. W. Siry.

The first paper in the book, on "Orbit Stability in Particle Accelerators," is by E. D. Courant. The problem is an interesting and important one and it is reassuring to find that the analysis presented here has been partly checked by numerical methods, even though these methods are not specified. The second article, "Motion of Cosmic-Ray Particles in Galactic Magnetic Fields" by S. Olbert, is linked to the first by the fact that the predominant force acting is magnetic in origin. It is not replete with theory, although it has a reasonable set of references.

The fifth paper, by Whipple, is entitled "Fundamental Problems in Predicting Positions of Artificial Satellites". It is another comment on the speed of publication that this article begins, "The . . . satellites of the IGY *will* be tracked . . ." (italics supplied). After discussion of tracking methods and of perturbations, Whipple mentions some "facts of life" of orbit calculation by machine. The discourse is illuminating, but all too brief.

Eckert's paper on "Numerical Determination of Precise Orbits" is better preceded by "History of", for it presents nothing that the unamended title suggests to this reviewer. It is, however, partly redeemed by a good bibliography.

"Comments on General Theories of Planetary Orbits", by Brouwer, is by far the best resumé of classical celestial mechanics to be published in a long while. Most parts will be clear even to the uninitiated, although more detail could be supplied on a minority of places. Brouwer shows himself, once again, to be a giant among his fellows.

The last paper, "Orbits in Birkhoff's Central Field", by C. Graef-Fernandez, brings us full circle by applying modern physics to planetary theory. It can be heartily recommended as an introduction to relativistic celestial mechanics.

In sum, the book has both its rewarding and disappointing aspects. It fills a long-existing need for review articles like Whipple's and (especially) Brouwer's and the bibliographies throughout. However, the less well-known techniques themselves are too quickly sloughed off, and the delay in printing has rendered the publication of some of the papers anticlimatic.

H. R. Westerman, Whippany, N. J.

391:

BAUMANN, R. **Automatisierte digitale Netzberechnung** (Automatized digital computation of power networks). *Elektronische Rechenanlagen* **2,** 2 (May 1960), 75–84.

Speed and storage capacity of modern digital computers make possible the automatic calculation of load flow, short circuit currents, stability, loss coefficients, and other network problems that arise in the design and operation of large power transmission systems. Working programs for a particular purpose are joined together from basic subprograms. The linkages are designed to permit the formation of a hierarchy of higher level programs from those of lower level to carry out successively more comprehensive calculations. Basic information to be supplied to the program consists of station names, the impedances of transmission lines joining them, and known and desired operating conditions. A consistent set of units is specified for the user. Any required scaling, normalization, or conversion to other bases is done internally. From the total number of stations and transmission lines, the program also automatically assigns necessary storage media such as core or drum. Beginning with the basic information, operation is completely automatic from the time the start button is pushed until the results are printed or punched. The programs were written in ALGOL and tested on a Siemens 2002 punched paper tape computer with a reading speed of 200 characters per second and a punching speed of 20 characters per second. Representative times for a network of 60 stations and 100 transmission lines were: Reading of network data—40 seconds; initial calculations, which include basic housekeeping such as storage assignments and matrix formation—60 minutes; reading of known operating data—26 seconds; modification for network changes—1 minute; calculation of load flow case—1 minute; printing of results—10 minutes.

The "initial calculations" apparently are a one-time investment from which many future calculations can be made with great facility. The time of one minute for a load flow case for a 60-bus, 100-conductor network is very respectable. Load flows for a 41-bus, 60-conductor system were computed in 20 seconds and for a 16-bus, 20-conductor network in 3 seconds. The author points out that it became apparent during the course of the work that neither knowledge of mathematical methods nor knowledge of the laws of power transmission by themselves, but only the combination of the two fields of knowledge offer sufficient guarantee for a technically usable and mathematically sound treatment of the problem. The work was done at the Institute for Applied Mathematics at the University of Mainz, Germany, where the author had the support and benefit of mathematical consultation by Prof. F. L. Bauer.

Martin Hochdorf, Chattanooga, Tenn.

392:

REXWORTHY, D. R.; AND KING, D. W. W. **Freeing**

city traffic. *New Scientist* (January 28, 1960), 197–199.

Could electronic computers be used to guide the traffic flow? It is proposed here that such a system could cut delays at intersections, indicate less congested alternative routes and enable road space to be apportioned according to the volume of traffic in each direction.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

393:

• KAZINSKIĬ, V. A. **Matematicheskie tablicy dlya approksimacii geofizicheskih anomalii i redukcii interpolyacionnymi mnogochlenami** (Mathematical tables for approximation of geophysical anomalies and reductions by interpolatory polynomials). Akademiya Nauk SSSR, Institut Fiziki Zemli. Izdat. Akad. Nauk SSSR, Moscow, 1959, 90 pp. 5.75 rubles.

The nine tables and one nomogram are designed to help the geophysicist compute the effect on the Newtonian gravity field of a large mass anomaly of irregular shape located in the earth's interior. Let

$$\rho = (x^2 + y^2 + z^2)^{-1/2}.$$

The largest table gives $10^{-3}/\rho$ to the nearest unit (about 3 significant decimals) for $x = 0(.25)3(.5)6$, 10, 15, 20, 25, 50, 100, 200, 500, for approximately 20 values (depending on x) of each of y and z. Other tables give x/ρ^3, z/ρ^3, y/ρ^3, and various functions like

$$xy(x^2 + z^2)^{-2}(y/\rho - y^3/3\rho^3).$$

There are also short tables relating the geoid to the spheroid.

There is an 18-page explanation of the use of the tables in geophysical calculations, but no indication of the accuracy or method of construction of the tables. The typography is not very good.

G. E. Forsythe, Stanford, Calif.

Courtesy *Math. Reviews*

394:

ARCHER, G. R. **Feedback and NOR logic yield sound spot welds.** *Electronics* **33,** 8 (Feb. 19, 1960), 48–51.

The basis efficiency of spot welding lies in the fact that heat is generated between the two parts, so that the bond between the two metal parts is formed from the inside out, in distinction to riveting or other fastening techniques, where the attachments are made from the outside in.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

395:

HARTREE, D. R. **The calculation of atomic structures.** John Wiley and Sons, Inc., New York, 1957, xiii + 181 pp., 23 cm. $5.00.

(Rev. 66, *Math. Comput.* **14,** 71 (July 1960), 299)

396:

GREENBERG, H. J. **Solving structural mechanics problems on digital computers.** *Structural Mechanics, Proceedings of the 1st Symposium on Naval Structural Mechanics,* Pergamon Press, 1960, pp. 533–556.

A short, critical survey of the current applications of digital computers to solving problems in structural mechanics, including a brief description of typical medium and large-size computing systems (IBM 650 and IBM 704); a list of standard mathematics problems to which structural mechanics problems commonly reduce for which adequate codes exist together with a list of these codes for both machines; an informal survey of mechanics codes completed and under development at representative centers; a detailed discussion of three advanced computer applications; and recommendations for future work in this field.

Courtesy *IBM J. Res. Develop.* **4,** 3 (July 1960)

397:

LEDLEY, R. S.; AND LUSTED, L. B. **The use of electronic computers in medical data processing: aids in diagnosis, current information retrieval, and medical record keeping.** *IRE Transactions on Medical Electronics ME-7*, 1 (January 1960), 31–47.

Some of the potential advantages of computer aids to medical data processing are: making available to the physician quantitative methods in areas relating to data analysis and differential diagnosis; assisting in the evaluation of the best alternative courses of action during stages of the diagnostic testing processes; making easily available to the physician reference to the most current information about new preventive measures.

Courtesy *Battelle Tech. Rev.* **9,** 6 (June 1960)

398:

• SANGREN W. C. **Digital computers and nuclear reactor calculations.** John Wiley and Sons, New York, 1960, 1 + 208 pp.

Although this book is devoted to a special subject, the first half gives a very clear treatment, suitable for the general user, of computers, programming, and numerical analysis. Many of the author's observations on these matters are very appropriate and are based on long experience in the computer field. The second half, while excellent, is highly specialized. The book will be welcomed by those in the nuclear reactor field.

Richard W. Hamming, Stanford, Calif.

399:

KELLER, HERBERT B. **Approximate solutions of transport problems. II. Convergence and applications of the discrete ordinate method.** *J. Soc. Indust. Appl. Math.* **8,** 1 (March 1960), 43–73.

The author continues his previous research (*J. SIAM* **6** (1958), 452–465) on approximating solutions of the transport equation. The monoenergetic neutron transport equation in plane geometry for an isotropically scattering

homogeneous medium can be written as

$$(*) \quad \frac{\partial\Phi(x,\mu)}{\partial x} + \sigma\Phi(x,\mu) = \sigma\frac{c}{2}\int_{-1}^{+1}\Phi(x,\mu)\,d\mu + S(x,\mu),$$

where $\Phi(x, \mu)$ is the neutron flux at position x whose velocity vector makes an angle $\cos^{-1}\mu$ with the positive x axis, σ is the total macroscopic cross section, c is the average number of secondary neutrons produced per collision, and $S(x, \mu)$ is an inhomogeneous source of neutrons. Basically, there are two well-known procedures for approximating the solution of this transport equations, one based on expansions in orthogonal functions of μ such as Yvon's method, and the other based on discrete ordinates in μ, and there is a certain equivalence between these methods. The author then investigates the discrete ordinate method, and he does this in a sufficiently general way so that all reported variations of the discrete ordinate method which are in use, are analysed. His basic result is a mean-square convergence theorem of the discrete ordinate methods to the solution of (*). The proof is valid for arbitrary non-homogeneous media.

Concentrating on the case of a homogeneous slab, the general solution of the discrete ordinate approximation is obtained by means of matrix calculus. For uniform sources, this general solution simplifies, and gives rise to a practical method of computation. Finally, for homogeneous gray slabs, an approximation for the neutron capture fraction is given, and asymptotic representations are obtained for very thick or very thin slabs. Also, the critical equation is derived and represented in a form which allows a simple numerical determination of the critical half-thickness of the slab.

Richard S. Varga, Cleveland, Ohio

400:

SELECTED TITLES FROM *Applied Mechanics Reviews:*

SNYDER, W. M. **Hydrologic studies by electronic computers in TVA.** *Proc. Amer. Soc. Civ. Engrs.* **86**, HY2 (J. Hydr. Div.) (February 1960), 1–10.
(Rev. No. 4402, *Appl. Mech. Rev.* **13**, 9 (September 1960) 626)

MCFARLANE, H. M.; AND GOTLIEB, C. C. **Backwater computations for the St. Lawrence power project, Part 1. Hydraulic engineering aspects of computation; Part 2, Backwater calculations on the Ferranti computer.** *Eng. J., Montreal* **43**, 2 (February 1960), 55–66.
(Rev. No. 4640, *Appl. Mech. Rev.* **13**, 9 (September 1960) 657)

• FINLAY-FREUNDLICH, E. **Celestial mechanics.** New York, Pergamon Press, Inc., 1958, viii + 150 pp. $7.50.
(Rev. No. 4885, *Appl. Mech. Rev.* **13**, 9 (September 1960), 691)

• KURTH, R. **Introduction to the mechanics of the solar system.** New York, Pergamon Press, Inc., 1959, ix + 177 pp. $6.50.
(Rev. No. 4886, *Appl. Mech. Rev.* **13**, 9 (September 1960), 691)

• BEER, A. (Editor) **Vistas in astronomy, Vol. 3.** New York, Pergamon Press, 1960, vii + 345 pp. $18.
(Rev. No. 4887, *Appl. Mech. Rev.* **13**, 9 (September 1960), 691)

Trajectory problems in cislunar space. AFOSR TN 59-1284 (Westinghouse Elect. Corp., Air Arm Div. TN-3678, DYD-95008), 42 pp., Dec. 1959.
(Rev. No. 4888, *Appl. Mech. Rev.* **13**, 9 (September 1960), 691)

ROSS, S. **Composite trajectories yielding maximum coasting apogee velocity,** ARS J. **29**, 11 (November 1959), 843–848.
(Rev. No. 4889, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

HUTCHESON, J. H. **Earth-period (24-hr) satellites.** *ARS J.* **29**, 11 (November 1959), 849–853.
(Rev. No. 4890, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

TEMPELMAN, W. **Comparison of minimum energy paths and apogee designation paths.** *ARS J.* **29**, 11 (November 1959), 865–868 (Tech. Notes).
(Rev. No. 4891, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

MOECKEL, W. E. **Departure trajectories for interplanetary vehicles.** NASA TN D-80 (November 1959), 35 pp.
(Rev. No. 4892, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

MIELE, A.; AND CAPPELLARI, J. O., JR. **Approximate solutions to optimum climbing trajectory for a rocket-powered aircraft.** NASA TN D-150, (September 1959), 56 pp.
(Rev. No. 4893, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

LOH, W. H. T. **Two simple equations for orbital mechanics.** *ARS J.* **29**, 2 (February 1959), 146–147 (Tech. Notes).
(Rev. No. 4894, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

LUKASJEWICZ, J. **Experimental investigation of hypervelocity flight,** Advances in Aeronautical Sciences, Vol. 1 (Proc. of the First International Congress in the Aeronautical Sciences, Madrid, Sept. 8–13, 1958). New York, Pergamon Press, 1959, pp. 127–186.
(Rev. No. 4895, *Appl. Mech. Rev.* **13**, 9 (September 1960), 692)

NIDEY, R. A. **Gravitational torque on a satellite of arbitrary shape.** *ARS J.* **30**, 2 (February 1960), 203–204 (Tech. Notes)
(Rev. No. 4896, *Appl. Mech. Rev.* **13**, 9 (September 1960) 692)

DOOLIN, B. F. **Gravity torque on an orbiting vehicle.** NASA TN D-70, 45 pp., Sept. 1959.
(Rev. No. 4897, *Appl. Mech. Rev.* **13**, 9 (September 1960) 692–693)

FRAEIJS DE VEUBEKE, B. **The problem of maximum range in a uniform gravitational field.** *Astronaut. Acta* **4**, 1 1–12, 1958. (French)
(Rev. No. 4898, *Appl. Mech. Rev.* **13**, 9 (September 1960) 693)

WESTERMAN, H. R. **Perturbation approach to the effect of the geomagnetic field on a charged satellite,** *ARS. J.* **30**, 2 (February 1960), 204–205 (Tech. Notes).
(Rev. No. 4899, *Appl. Mech. Rev.* **13**, 9 (September 1960) 693)

TRAENKLE, C. A. **Mechanics of the power and launching phase for missiles and satellites.** *Ing.-Arch.* **28**, (March 1959), 335–336. (English)
(Rev. No. 4900, *Appl. Mech. Rev.* **13**, 9 (September 1960) 693)

STATISTICS

401:

• PARZEN, EMANUAL. **Modern probability theory and its applications.** John Wiley & Sons, Inc., New York, 1960, xv + 464 pp. $10.75.

The author has produced a commendable and authoritative text and reference work on the theory and applications of probability theory. The approach is the modern axiomatic one. Customary subject matter in a first year probability text is enriched by additional material at the end of each chapter such as Markov chains, birth and death processes and conditional distributions and expectation. Chapters 9 and 10, "Sums of Independent Random Variables" and "Sequences of Random Events," constitute more advanced material presented with clarity and vigor. A useful feature is the inclusion of about 800 examples, theoretical exercises, and numerical problems. Answers are provided to odd-numbered problems, and are available from the publishers to the even-numbered problems. Typography and drawings are clear and attractive. The book appears to be a tribute to careful proofreading; the only misprint noted was the use of X for U on the second line of page 388. Parzen's book takes a rightful place in Wiley's worthy publications in Statistics.

Jack Moshman, Arlington, Virginia

402:

CASHWELL, E. D.; AND EVERETT, C. J. **A practical manual on the Monte Carlo method for random walk problems.** Pergamon Press, New York, 1959, 152 pp., 23 cm. $6.00.

(Rev. 62, *Math. Comput.* **14**, 71 (July 1960), 299)

TECHNOLOGICAL EFFECTS AND CYBERNETICS

403:

• BEER, STAFFORD. **Cybernetics and management.** John Wiley & Sons, Inc., New York, 1959, xv + 214 pp. $4.50.

It is all too infrequent that one encounters a book on such a relatively new and technical subject as cybernetics that is as readable and informative as *Cybernetics and Management.* The title is indicative of the audience the author had in mind. Mathematical detail in the form of equations and symbols is reduced to a bare minimum; how can one discuss the quantitative aspects of information theory with writing $H = -\Sigma p \log p$? The author supplies a solid foundation to the science of cybernetics leading into discussions of the industrial potential. The text is illustrated by clear line drawings which help explain some of the critical points in the exposition. As Head of the Department of Operational Research and Cybernetics at the United Steel Companies, Ltd., Beer speaks with authority and fervor. The latter quality may best be illustrated by the chauvinistic conclusion to the preface:

> The context of this phase in cybernetic development is clear. The highly industrialized societies of the West are due to meet intense pressure, economic and ethnic, from the East. It is difficult to speak of these matters in a sophisticated society without sounding absurdly sententious, but somehow we have to survive in a world where the opposition is prepared to throw human comfort, security and dignity into the balance—which we are not. Countries such as Russia and China are prepared to pour the national income into research and development, whatever the standard of living—which we are not. Therefore they are absolutely certain to eclipse the more hedonistic West in the end—unless we can keep the lead we have traditionally held in the exploitation of the human intellect.
>
> The signs are frankly bad. The tremendous rate of advance in Russia, for instance, has not been the product of iron resolve and self-abnegation alone. Sputniks are not sent into orbit by fasting and prayer. In Britain there is little to claim in such fields as space research, because there is never enough money for the programmes required. In the field of industrial production, new methods and inspired management are sometimes said to have transformed British industry. The fact remains that the index of industrial production has not moved up for four years. We desperately need some radical new advance, something qualitatively different from all other efforts, something which exploits the maturity and experience of our culture. A candidate is the science of control. Cybernetic research could be driven ahead for little enough expenditure compared with rocketry, for example. And if we do not do it, someone else will.

Polemics aside, the author has written a book which is to be highly recommended to all those interested in the science of control and its implications.

Jack Moshman, Arlington, Virginia

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POLONSKY, J. **Essai d'interpretation du fonctionnement** (An interpretation of the functioning of living cells in the framework of quantum cybernetics). *Cybernetica* **2,** 2 (1959), 75–97 and **2,** 3 (1959), 162–194.

This paper presents a "microcybernetic system", based on principles of electromagnetism and quantum mechanics, for the purpose of explaining a great number of biological phenomena as observed in the living cell. The author, through this system, attempts to provide a coherent interpretation in a physical sense, of the terms "resonance", "selectivity", and "code" as used in biology. Based upon this hypothesis, he claims that the boundary between living and nonliving matter resides in the transformation of certain macromolecules in the living cell into sources of coded information capable of affecting other systems. According to the model, life in its physical aspects is entirely dominated by the phenomena of electromagnetic resonance as determined by the laws of quantum mechanics. Having established the model, the author proceeds to interpret certain biological phenomena in the light of the hypothesis. In particular, he considers biosynthesis, the functioning of proteins, mitosis, mutation, memory, and the effects of viruses. He poses the question of how the validity of the hypothesis can be experimentally verified and has a number of suggestions along these lines, including, in particular, a study of electromagnetic emissions from nucleic acid and of the specific effect of them on proteins. The model described in this paper is quite stimulating and very much in the tradition of Erwin Schrödinger and others in the quantum theory of chemical bonds.

R. M. Hayes, Sherman Oaks, Calif.

Titles of Papers Reviewed In *Referativnyi Zhurnal, Matematika Referaty, January–June, 1959*

TRANSLATED BY ARTHUR E. OLDEHOEFT, *Chapel Hill, North Carolina**

TRANSLATOR'S NOTE: The following are titles of articles pertaining to *Numerical and Graphical Methods* and *Computers and Mechanical Devices* which have been reviewed in the Soviet Mathematical Reference Journal. Appearing with each reference is the number; this will facilitate recovery of the original in Russian. The transcription system used for the transliterated portions is the standard set down by the Library of Congress. *Matematika Referaty* is the Soviet abstracting journal comparable to the American Mathematical Society *Mathematical Reviews*.

Numerical and Graphical Methods

866. Application of a method of grids in the study of motion of heavy fluid with a free surface. Dumitresku D., Ionesky, V., and Tott, P. *Zh. prikl. mekhan. Akad. RNR* (Journal of Applied Mechanics of the Academy of the Rumanian People's Republic), 1956, *1*, No. 2, 43–81.

869. On a method of accurate and two-sided approximation to solution of parabolic equations. Saul'ev, V. K. *Dokl. AN SSSR* (Reports of the Academy of Sciences, USSR), 1958, *118*, No. 6, 1088–1090.

873. Remark on one estimation of L. V. Kantorovich. *Tsaliuk Z. B. Ych. zap. Udmurtsk. gos. ped. in-ta* (Educational Notes of Udmurt's State Teacher's Institute), 1957, extract, 127–128.

890. Application of polynomials for mathematical characteristics of the relief of the Earth's surface. Kheifets, B.S. *Izv. vyssh. uchebn. zavedenii. Geod. i aerofotos* (Information of the Institution of Higher Education of Geodesy and Aero-photography), 1958, No. 1, 79–86.

893K. Thesis of reports on the Council on Computing Mathematics and the application of the means of computing techniques. Baku, 1958. AN AzerbSSR vychisl. tsentr. AN SSSR, In-t avtomatiki i telemehkan. AN SSR. Baku, AN AzerbSSR (Academy of Science of Azerbaijan SSR, Computing Center. Academy of Science USSR, Institute of Automation and Telemechanics. Academy of Science USSR), Baku, Academy of Science Azerbaijan SSR, 1958, 64 pp. Free of charge.

894D. Certain difference schemes for the solution of first boundary problems for linear differential equations with partial derivatives. Iuand, Chao-din. *Avtoref. diss. kand. fiz-matem. n. MGU*, M. (Authorized dissertations of candidates of Physics and Mathematical Sciences, Moscow State University, Moscow) 1958.

2006. Difference methods for the solution of non-linear problems. Budak, B. M., Gorbunov, A. D. *Uspeki matem. nauk* (Progress of Mathematical Sciences), 1958, *13*, No. 4, 223–225.

2012. Method of majorants for analytic operators in application to modification of processes. Khalitova, N. A. *Uch. zap. Kazansk. in-ta* (Educational Notes of Kazan Institute), 1957, *117*, No. 9, 14–16.

2022. On the method of chords constructed by means of Chebychev points. Derendiaev, I. M. *Izv. vysh. uchebn. zavedenii* (Information of the Higher School of Learning), *Matematika* (Mathematics), 1958, No. 2, 52–60.

2032. Methods of solution of problems on the theory of elasticity during which are obtained upper and lower bounds for the unknown values. Svirskii, I. V. *Uch. zap. Kazansk. in-ta* (Educational Notes of the Kazan University), 1957, No. 9, 17–21.

2040D. On the solution of the equation of Laplace in an ellipse and ellipsoidal regions. Vzorova, A. I. *Avtoref. diss. kand. fiz.-matem. n., In-t tochnoi mekhan. i vychisl. tekhn.* AN SSSR, M. (Authorized dissertations of candidates of Physics and Mathematical Sciences, Institute of Precise Mechanics and Computing Techniques. Academy of Science USSR, Moscow), 1958.

3232. On longitudal vibrations of filaments with variable masses on the end. Iushchenko, A. A. *Ukr. matem. zh.* (Ukrainian Mathematical Journal), 1956, *8*, No. 4, 460–462.

3236. An approximate method of solution of problems of thermal conduction, Veinik, A. I. *Inzh.-fiz, zh.* (Engineering and Physics Journal), 1958, *1*, No. 2, 3–12.

3237. Solution of parabolic equations of arbitrary order by the method of grids. Saul'ev, V. K. *Dokl. AN SSSR*, (Reports of the Academy of Science USSR), 1958, *119*, No. 4, 655–658.

* The work done in this translation was supported by the National Science Foundation under a grant to the Computation Center, University of North Carolina, Chapel Hill, North Carolina, to study computing techniques in the Soviet Union.

3251. Remark on the work of M. N. Nechepurenko "On the question of convergence of approximate methods". Khalitova, N. A. *Uch. zap. Kazansk. in-ta* (Education notes of Kazan University), 1957, *117*, No. 2, 79–82.

3255. Quadrature formulas for calculation. Karpov, A. B. *Tr. Gor'kovsk. politekhn. in-ta* (Works of the Gor'kov Polytechnic Institute), 1958, *14*, No. 1, 23–33.

4212. On the convergence of certain finite difference processes for the equation $y' = f(x, y)$ and $y'(x) = f(x), y(x), y(x - t(x))$. Gorbunov, A. D., Budak, B. M. *Dokl. AN SSSR* (Reports of the Academy of Science USSR), 1958, *119*, No. 4, 644–647.

4213. Application of the method of oscillatory functions and approximate solution of initial and boundary problems for non-linear differential equations of second order. Sharkova, N. V. *Izv. vyssh. ychebn. zavedenii Matematika* (Information of School of Higher Learning, Mathematics), 1958, *3*, 251–255.

4216. Adaptation of theorems of Chaplygin about differential inequalities to the solution of first boundary problems for linear equations of the elliptic type. Zagainov, L. S. *Izv. vyssh. uchebn. zavedenii Matematika* (Information of School of Higher Learning, Mathematics), 1958, *3*, 96–98.

4217. On the approximate solution of equations of the elliptic type. Maiorov, I. V. *Izv. vyssh. uchebn. zavedenii, Matematika* (Information of Schools of Higher Learning, Mathematics), 1958, *3*, 160–162.

4221. Solution of problems of plastic torsion by method of solutions in finite differences. Ivanov, S. I. *Tr. Kuibyshevsk. aviats. in-ta* (Works of the Kuibyshev Aviational Institute), 1958, extract 4, 59–67.

4232. Application of a combined approximation method of the solution of integral equations to a problem of structural mechanics. Vorontsov, G. V. *Tr. Novocherk. politekhn. in-ta* (Works of the Novocherk. Polytechnic Institute), 1958, No. 78/92, 3–10.

4233. Approximate solution of certain aspects of non-linear integral equations. Bel'tiukov, B. A. *Uch. zap. Blagoveshch. gos. ped. in-ta* (Educational Notes of Blagoveshch. State Teacher's Institute), 1956, *7*, 51–56.

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4256. Certain remarks about a method of integration. Friedman, A. A., *Uch. zap. Riazansk. gos. ped. in-ta* (Educational notes of the Riazan. State Teachers Institute), 1958, *15*, 45–54.

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4267. On the estimation of errors in the approximate theory of non-uniform linearity. Orlov, S. I. *Radiotekhnika* (Radio-technology), 1958, *13*, No. 10, 9–13.

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4272. On approximate functions in the light of new computing techniques. Postoeva, N. I. *Izv. Leningr. elektrotehkn. in-ta* (Information of Leningrad Electro-technological Institute), 1958, extract 35, 222–230.

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5218. On a method of solution of a system of linear algebraic equations. Byrdina, V. I. *Dokl. AN SSSR* (Reports of the Academy of Science, USSR), *120*, No. 2, 235–238.

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6303. On the speed of convergence of an integration process for the difference solution of the problem of Dirichlet for the equation of Laplace. Aleksidze, M. A. *Dokl. AN SSSR* (Reports of the Academy of Science USSR), 1958, *120*, No. 1, 9–12.

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7492. On the existence of the solution of the problem of general anamorphosis. Smirnov, S. V. *Dokl. AN SSSR* (Reports of the Academy of Science USSR), 1957, *116*, No. 3, 359–363.

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2147. International Council on the question of application of electronic computing machines for adaption of statistical data. Belkin, N. *Vesti. statistiki* (News of Statistics), 1957, No. 3, 86–89.

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9515. The calculation of higher partial derivatives of complex functions. Iarov-Iarovoi, M. S. *Vestn. Mosk. Un-ta. Ser. Matem., Mekhan., Astron., Fiz., Khimii*, 1958, No. 1, 87–95.

Computing Machines and Mathematical Instruments

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9604. The application of computing devices for automatic blast furnace production. Kaganov, V. Iu. *Avtomat. Upravlenie i Vychisl. Tekhn. M.* Mashgiz, 1958, 310–320.

9605. The automatic regulation of the size of lamination of metal. Cheliustkin, A. B. *Avtomat. Upravlenie i Vychisl. Tekhn. M.* Mashgiz, 1958, 340–361.

9614K. The prospective application of management machines in automatization. Bruk, I. S. M. AN SSSR, 1956, 17 p. (no charge)

9615K. *The Solution of Static Indeterminate Systems on a Small Computer*. Narets, L. K. M., Gosstroiizdat, 1958, 62 p. 2r. 10 k.

TRANSLATION OF SOVIET PUBLICATIONS IN THE AREA OF COMPUTERS*

A. E. Oldehoeft, *Chapel Hill, North Carolina*

This article presents a summary of U. S. translation activity in the field of high-speed computers. The information for the most part has been extracted from the document "Providing U. S. Scientists with Soviet Scientific Information,"[1] which discusses the general availability of Soviet scientific literature. Cover-to-cover translation of a number of Soviet journals is currently sponsored by various agencies. Listed below are those journals which carry information concerning computers and mathematical machines.

In addition, an important monthly journal of abstracts is the *Referativnyi Zhurnal.* In the category of general mathematics, it published 9,035 abstracts in 1957, and 10,925 in 1958. Included in this category are the abstracts carried under the subheadings:

1. Numerical and Graphical Methods
2. Computers and Mechanical Devices
3. Utilization of Computers and Mechanical Devices

Title translations of the listings under these three subheadings are currently published in *Computing Reviews.*

Two main translation depositories in the U. S. are:

1. Special Libraries Association Translation Center (SLA), The John Crerar Library, Chicago, Ill.
2. Office of Technical Services, (OTS), Technical Information Division, Department of Commerce, Washington 25, D. C.

The SLA collects translations from non-government sources such as industrial organizations, universities, and professional societies, while the OTS collects translations from government and foreign sources. A listing of the translations in both depositories along with their abstracts can be obtained from the OTS at 60 cents a copy or $12 per year.

Other guides to information sources in the U. S. are:

1. *Translators and Translations: Services and Sources,* a book published by the SLA which contains a directory of translators and translation pools, and a bibliography of translation indexes.
2. *Providing U. S. Scientists with Soviet Scientific Information.*[1]

Publications from the Soviet Union may be obtained through the following dealers, among others:

(1) Victor Kamkin Bookstore, 2906 14th St., N. W., Washington, D. C.
(2) Four Continents Book Corp., 822 Broadway, New York 3, N. Y.
(3) Imported Publications and Products, 4 West 16th St., New York 11, N. Y.
(4) Moore-Cattrell Subscriptions Agencies, Inc., North Coshocton, N. Y.
(5) Universal Distributors, 52–54 West 13th St., New York 11, N. Y.
(6) Stechert-Hafner, Inc., 31 East 10th St., New York 11, N. Y.
(7) A. Buschke, Books, Serials, Chess Literature, 80 East 11th St., New York 3, N. Y.
(8) Collet's Holdings, Ltd., 44 & 45 Museum, London, W.C. 1, England.

Title	Frequency	Agency	Sponsor	Price
1. Prikladnaia Matematika i Mekhanika (Journal of Applied Mathematics and Mechanics)	Bimonthly	American Society of Mechanical Engineers	NSF	$35/yr
2. Avtomatika i Telemekhanika (Automation and Remote Control)	Monthly	MIT	NSF	$30/yr, $15/yr to university libraries
3. Electrichestvo (Electric Technology)	Quarterly	Pergamon Institute		$56/yr
4. Priborostroenie (Instrument Construction)	Monthly	British Scientific Research Associates		£6./yr
5. Pribory i Tekhnika Eksperimenta (Instruments and Experiment Techniques)	Bimonthly	Instrument Society of America	NSF	$25/yr, $12.50 to libraries of academic inst.
6. Radiotekhnika (Radio Engineering)	Monthly	MIT	NSF	$30/yr, $15 to lib. of acad. inst.
7. Radio Tekhnika i Elektronika (Radio Engineering and Electronics	Monthly	MIT	NSF	$45/yr, $22.50 to lib. of acad. inst.
8. Stanki i Instrument (Machines and Tooling)	Monthly	Production Engineering Research Associates, England		£3.10.0/yr in England, £4.4.0 outside
9. Vestnik Mashinostroeniia (Bulletin of Machine Building—Russian Engineering Journal)	Monthly	Production Engineering Research Associates, England		£4./yr
10. Selected Translations of Russian Mathematics Articles	Bimonthly	American Mathematical Society	NSF	Approx. $5/volume

* This work is supported under a grant from the National Science Foundation.

[1] The revised edition, May 1959, is available from the Office of Science Information Service, National Science Foundation, Washington 25, D. C.

Note on Acquisition of Soviet Publications

Additions to the book dealers listed on the previous page are:

(1) Znanie Book Store, 5237 Geary Blvd., San Francisco 18, California

(2) Les Livres Etrangers, 10, rue Armand-Moisant, Paris 15, France

These two sources were pointed out by George Forsythe, Stanford, California, in a letter to *Computing Reviews.*

Arthur E. Oldehoeft, Chapel Hill, N. C.

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Mathematical Investigations Related to the Use of Electronic Computing Machines

A. A. LIAPUNOV, *Matematika v SSSR za Sorok Let 1917–57*, Moscow, 1959, pp. 857–877.

(Translated by MORRIS D. FRIEDMAN, *West Newton, Mass.**)

Computational technique in the past decade has been enriched by new high-powered facilities, electronic computers. The result has been to make possible today the computational solution of such problems as were completely inaccessible ten to fifteen years ago. In this connection, an unique revaluation has taken place in applied mathematics. Many mathematical methods which had led to unwieldy computation and which had earlier been considered ineffective now appear to be completely workable. On the other hand, purely analytic constructions leading to inconvenient computational algorithms lost their value in a certain time in every case. In this connection, many new questions arose which were related to the development of methods to solve mathematical problems which would be applicable to machines. These works are considered in the paper on 'Approximate and Numerical Methods' and are not the subject of the present paper.

However, in addition, new problems arose in mathematics for which the source was the utilization of computers. These problems were posed in connection with the necessity to develop such methods of using machines that their productivity would be optimal and also in connection with the desire to solve as broad a circle of problems as possible on the machines, without being limited to purely computational problems. Machines can perform various logical operations and, with skillful use, they can lighten the intellectual labor of mankind in very different areas. Finally a large circle of interesting mathematical questions arises from the soil of designing computers. All the problems enumerated refer to a number of mathematical questions of cybernetics, a mathematical science which emerged in recent years and which studies control systems and control processes.

We have just undertaken systematic scientific work in cybernetics in the past five years. It should be kept in mind that much of value in this branch has been contributed by engineers who are occupied with planning and utilizing various control apparatus. Unfortunately, we have had no opportunity to collect any kind of complete survey of all these works. Consequently, we preferred to leave engineering work aside and to limit ourselves to the consideration of just the mathematical work on cybernetics. Hence, we will limit ourselves just to works referring directly to electronic computers and which are mathematical in nature. Such a limitation would thus lead to those works being analyzed in the present survey which, basically, were executed in the cybernetics group of the V. A. Steklov Mathematics Institute AN USSR (MIAN) and in certain organizations working in close liaison therewith.

The survey consists of four sections:

1. Theoretical investigations from the programming branch.
2. Nonarithmetical utilization of computers.
3. Theoretical investigations of control (or guidance) systems.
4. Certain other problems of mathematical cybernetics.

The third section is very closely allied to certain sections of the paper, 'Mathematical Logic and Foundations of Mathematics'.

In October, 1957, S. V. Iablonskii presented a survey report to a conference on relay-contact circuits in the Institute of Automatics and Telemechanics AN USSR (IAT) on the work of MIAN in this area. Section 3 herein is a reprint of this report, to a considerable degree. O. S. Kulagina and T. N. Moloshnaia helped in the preparation of section 2, and M. L. Tsetlin and O. B. Lupanov in that of section 3.

The designation cybernetics combines many related, but nevertheless, heterogeneous problems which are often studied independently. The central concept of cybernetics is the concept of a control system. Moreover, the basic material underlying the mathematical problems of cybernetics consists of the study of the general properties of abstract control systems. From this soil there emerges in a natural manner the further problem of separating the classes of control systems which have some kind of properties essential in applications and of studying the correlation between these classes as well as of methods of investigating and synthesizing control systems from these classes.

S. V. Iablonskii made an interesting attempt to give an exact definition of the concept of a control system. The

* This translation was prepared for the Electronics Research Directorate, Air Force Cambridge Research Center, Air Research and Development Command, United States Air Force, Bedford, Mass.

definition he proposed includes all control systems known at the present time. Particular examples of control systems are electronic and relay-contact circuits, the nervous system, computational algorithms, programs, algorithmic solutions of certain problems containing random experiences, etc.

Taken into account in the S. V. Iablonskii definition are the topology of the systems, their functional peculiarities as well as the algorithms controlling their functioning. Unfortunately, the structure of this definition is much too complicated for it to be reproduced here. In its design, it is found in the same relation to actual control systems as, according to the thesis of Church, the abstract definition of algorithm (recursion, Turing machine) is to the real algorithms used in mathematics.

1. Theoretical Investigations on Programming

The fact that every program, no matter how complicated, is constructed from a large number of individual parts which are interrelated very complexly causes great difficulty in practical programming. Consequently, in direct programming it is necessary to visualize clearly the structure of the program as a whole and its status at all stages of the research.

In this connection the problem arose of breaking up the programming process into constituent parts so that programs for the different parts of the problem could be composed in as autonomous a manner as possible and then the program as a whole could be synthesized therefrom. Various approaches to the solution of this problem were developed in Moscow (A. P. Ershov, 1956–1957; A. A. Liapunov, 1952–1953; R. I. Podlovchenko, 1956–1957; IU. I. Ianov, 1955–1956), in Leningrad (L. V. Kantorovich, L. T. Petrova and V. A. Bulavskii, 1955–1957) and in Kiev (L. A. Kaluzhnin, 1956–1957).

We shall briefly explain the content of these researches.

1. The apparatus of logical program schemes (operator programs) was developed in the Mathematics Institute AN USSR in Moscow. This method is widely used in practice at the present time. It consists of the following: The algorithm solving the problem is broken up into a number of elementary acts, each of which is simple enough so that it could be programmed directly. The order of performing these acts can depend on any kind of conditions. The piece of the program which executes each individual act of the algorithm is called the computation operator. The piece of the program performing the checking of any of the conditions on which the order of execution of the operators depends is called a logical condition (or logical operator).

Often some of the operators depend on certain parameters, wherein different executions of the same operator occur for different values of these parameters. Most often, the regular change of this operator by unity corresponds to the successive execution of the same operator.

In order for the machine to be able to perform the computation operation in turn, it is necessary that the state of the memory be such as the operation requires.

In this connection, special control operations are introduced. These pieces of the program, which prepare the state of the machine memory for the performance of the computation operations. The whole program is synthesized from computation operations, control operations and logical conditions.

The following symbolism is used: Computation operations are denoted by upper case Latin letters, their dependence on parameters are indicated by subscripts: A, B_i, C_{ij}, etc. Logical conditions are denoted as variables of logic algebra or as logical predicates by lower case Latin letters: p, q, $p(x > y)$, etc.

Control operations are also denoted by upper case Latin letters, wherein what is the content of functions of this operation is indicated in parenthesis. In the majority of cases, control operations of certain standard kinds are used in programs and standard symbols are used for their notation. Thus, $F(i)$ denotes the operation which increases the parameter i by one wherever this parameter figures in the program. The operation which reproduces the initial value of the parameter wherever it occurs in the program is denoted by $O(i)$. The operation which forms the operation A according to existing preparations is denoted by $\phi(A)$.

A line of operations and logical conditions provided with arrows which specify the order in which the operations must be executed in order to accomplish the programming algorithm in the following sense is called a program scheme. Let us call the separate operations terms of the scheme and let us call the logical conditions its constituents. An arrow must proceed from each logical condition to one of the terms of the scheme or to its terminus.

The order of operation of the terms of the scheme is determined as follows:

(1) The extreme left-hand term of the scheme is performed first.

(2) Furthermore, if the next of the executed terms were to be an operation, then the term of the scheme on its right is to be performed.

(3) If the next of the executed terms were a logical condition, then two cases are possible:

(a) If the conditions under consideration were to be true, then the term of the scheme directly to its right is executed;

(b) If it were to be false, then that term of the scheme is executed to which the arrow is returned.

(4) A vacant space after the extreme right-hand term of the scheme is considered as an operation cutting off the machine.

Let us cite an example of a program scheme.

Let us consider the problem of multiplying square matrices of order n:

$$\|a_{ij}\| \times \|b_{jk}\| = \|c_{ik}\|$$

The first two matrices are written in some of the regis-

ters. Specific registers are also eliminated for the third matrix. Zeroes are inscribed therein at the initial instant. Let the operations A_{ijk} calculate the product $a_{ij} \times b_{jk}$, and let us add it to the contents of the register intended for the element c_{ik}. Then the program scheme can be constructed thus:

$$\downarrow\downarrow\downarrow A_{ijk}F(j)p(j > n)\,(O(j)F(i)p(i > n)\,O(i)F(k)p(k > n)$$

The compilation of a program must be started with the development of a detailed program scheme. After a detailed program scheme has been constructed, each operation can be programmed separately. Here, it must be indicated what is the dependence of the operations on the parameters. This dependence most often reduces to certain commands containing an address depending linearly on the parameters. An exact indication of the dependence of the addresses on the parameters permits control operations to be constructed automatically. G. P. Bagrinovskaia (1954) has shown that construction of the control system of a program can be performed by the machine itself according to a special compiler program if the program scheme is given, the computation operations are programmed and the dependence of the addresses of these operations on the parameters is indicated.

Later, M. R. Shura-Bura, E. Z. Liubimskii, S. S. Kamynin and others constructed compiler programs which completely construct the whole working program containing the program scheme and certain special information on the structure of the computation operations.

2. If the program structure is basically dependent on the program scheme, since the realization of a program according to a prepared scheme is performed automatically then the question of constructing the most suitable programs reduces, to a considerable extent, to the ability to construct logical schemes which would guarantee efficient program construction.

It must be kept in mind that the requirements imposed on the program are very diverse. To a considerable extent, they depend on the machine and even on its region of exploitation. At the same time, it is important that there be the possibility of selecting expedient program schemes without relying on the programming of various comparable variations. In this connection it is important to be able to transform the program scheme in an equivalent manner and to estimate the program being obtained according to the form of its logical scheme.

The latter is not difficult in a first approximation. It would appear to be much more difficult to develop methods of formally transforming program schemes.

This problem decomposes into two parts. The first is to construct such transformations by considering that the operations composing the program remain invariant but only the form of the logical conditions is changed. Such transformations have been studied by IU. I. Ianov.

The second part consists of constructing transformations of program schemes taking identical relations between operations into account. These transformations are intended to perfect the structure of the control operations and the system of program control. The first steps in studying such transformations have been made by R. I. Podlovchenko, N. Arsent'eva and N. A. Krinitskii.

Let us give a representaton of the IU. I. Ianov transformations.

Let us assume that the logical conditions in the program scheme are functions of certain other logical variables. Then the verification of the original logical conditions can be replaced by the verification of the new conditions if only the requisite control transfers have been matched, for example, $(p \cdot q)\,B\downarrow$ and $p\,q\,B\downarrow\downarrow$. Two such schemes are equivalent. Here are examples of equivalent pairs of schemes:

$$(p \vee q)\,B\downarrow \quad \text{and} \quad \bar{p}\,q\downarrow B\downarrow$$

$$(p\cdot)\,B(p\bar{q})\,C\downarrow\downarrow \quad \text{and} \quad p\,q\,B\omega\downarrow C\downarrow\downarrow$$

(ω always denotes an identically false condition). IU. I. Ianov constructed a system of rules with the use of which any two equivalent program schemes can be transformed into each other (in the absence of relations between operations).

3. L. A. Kaluzhnin proposed another means of writing algorithms. The algorithm is decomposed into elementary acts which are of two types. One of them revises the information and the other determines the subsequent operating sequence. Each operation, which performs a certain act which can appear in the algorithm, is mapped by a point on a plane.

If the operation B should necessarily follow the operation A, then an arrow is drawn from the point A to the point B. If one of two given operations can follow a certain operation which checks some kind of condition, then arrows are drawn from the point corresponding to the first operation to both the subsequent operations and they are marked with the symbols 'yes' or 'no'. The set of all these arrows and markers with the indication as to which operation any node maps bears the designation of the graph-scheme of the algorithm. L. A. Kaluzhnin and his students study methods of representing various algorithms in the form of graph-schemes, methods of constructing programs according to a given graph-scheme with automatic programming as the aim, and also methods of the formal transformation of graph-schemes of programs.

4. Still another approach to the question of formalizing the writing of a program structure has been developed in researches of A. P. Ershov. The substance of the matter is this: A set of variables, a set of acts which revise the values of these variables, and a set of conditions which determine the order in which the elementary acts operate as a function of the values of the variables are all introduced.

It is essential that the revised variables can, in turn, be codes of the revised acts. The set of values of the variables which revise the acts and the logical conditions is called the computing algorithm. The basic difference between the A. P. Ershov construction and that of L. A. Kaluzhnin is that the computing algorithm is capable of revising the intrinsic logical scheme while the graph-scheme remains unchanged during operation since all possible logical paths have been provided therein beforehand. From the content viewpoint, it appears that both the graph-scheme and the computing algorithm are equivalent to the standard representation of algorithms in mathematical logic, i.e., if no limitation is imposed on the volume of the memory apparatus, then both these concepts are equivalent to the concepts of the Markov normal algorithm, the Church recursions or the Turing machine.

The concept of the computing algorithm has been constructed so that it reflects the program structure for computing machines in a very natural manner, without drawing upon individual peculiarities of the machines.

Relying on this concept, A. P. Ershov developed a system of programming, which led to total automatization. This system is realized in a compiler program which differs in that it requires only that the computation scheme be prescribed in order to program problems in which the calculations are of a cyclic character, while the compiler program itself selects the program scheme which will perform these cyclic calculations. Consequently, the program schemes to which this compiler program leads are less diverse than that permitted by the compiler program constructed by M. R. Shura-Bura, E. Z. Liubimskii and S. S. Kamynin whereas the preparation of simple problems for programming by using the A. P. Ershov compiler program is simpler. The further development of the theory of computing algorithms holds great promise.

5. The investigations of L. V. Kantorovich on programming pursued two ends: On the one hand, the question was posed of decreasing the excessive labor expended in composing the program, and on the other, there was the tendency to broaden the possibilities of machines in an essential way by providing it with not only numerical computations but also with a considerable part of analytic calculations or logical reasoning.

L. V. Kantorovich succeeded in combining these and other possibilities in the programming system he developed which is based on the utilization of special interpretive programs, called 'prorabs'[1]. The idea behind this method is the following: The programming algorithm is pictured as a unique tree whose individual branches reflect quantities in the algorithm and the junctions denote operations which must be performed on the input quantities in order to obtain the output quantity. This tree is coded in a special, particularly compact manner. The 'prorab' explains which quantities are known and by disclosing that all the initial data for a certain operation are ready, constructs the program which will perform the required calculation. Machine operation was broken up in the first variations of the 'prorab' so that the working program was quickly executed after which the control was again transferred to the 'prorab'. In new variations of the 'prorab', the working program can be stored and extracted to the outside for independent utilization. The 'prorab' must have prepared sub-programs which can be used to perform operations composing the algorithm. It is necessary to note that the separate, initial data can be not only numbers but vectors, matrices or multidimensional matrices as well. The operations performed can be not only the ordinary computing operations but also completely arbitrary operations which recode the information. It is only necessary that sub-programs performing these operations be already prepared. Thus, for example, by using 'prorabs' the machine can be made to solve differential equations with a small parameter by expanding the solution in powers of the parameter where the coefficients are found as complex analytic expressions containing indefinite integrals. These coefficients can either be tabulated or extracted from the machine in analytic form.

The 'prorab' method is especially convenient for experimental computation when it is necessary to have the possibility of constructing rapidly the program by which the computations must be made a small number of times. Only finally will the postponed variation of the computation be used multiply. Under such conditions, a certain additional expenditure of machine cycles, unavoidable when using a 'prorab', is not dreaded. Apparently the systematic use of 'prorabs' is very advantageous for the production of sample calculations in the machine.

6. Much research is also being conducted in the Soviet Union on practical programming and on the perfection of programming method, in particular, on various methods of automating programming. A number of different variations of the compiler program have particularly been developed. In addition, much research has been performed relative to using the method of standard programs. However, this research has not yet led to the formulation of independent mathematical problems. In the present survey we have only dwelt on those researches on programming as have appeared directly in theoretical investigations of a mathematical nature.

2. Nonarithmetic Uses of Computing Machines

1. Theoretical Investigations on Machine Translation from Some Languages to Others

In principle, a computer is capable of performing any revision of information if only an algorithm is written according to which this revision of the information should be performed. Only the volume of the memory can limit the possibilities of the machine. However, of enormous value in practice is how great a machine capacity can be guaranteed in any specific case. It is very important to

[1] Translator's Note: Prorab is probably an abbreviation of "programmiruiushchaia rabota", programming operation.

learn to guarantee highly effective machine operation for the greatest possible variety of information revision. To do this, it is necessary to turn definite attention to the various experiments on using machines to revise information.

Of particular interest is the formulation of experiments by which the machine performs some kind of function of the human intellect. Consequently, it is tempting to transmit as great a variety as possible of the uses of human speech by machine.

In principle, it is precisely from this viewpoint that the translation of texts from some languages to others by using computers is of interest.

Machine translation from foreign languages into Russian has been worked out at the present time by a collective of co-workers of the Instituta tochnoi mekhaniki i vychislitel'noi tekhniki AN USSR (ITM i VT—Institute of Exact Mechanics and Computation Techniques) and a collective of co-workers of MIAN consisting of O. S. Kulagina, T. N. Moloshina, G. P. Bagrinovskaia in collaboration with I. A. Mel'chuk (Institut iazykoznaniia AN USSR—Institute of Languages).

These groups travel somewhat different roads. The fundamental tendency in ITM i VT is the most rapid realization of the effect of a human translator by the road of maximum imitation. The fundamental tendency in MIAN is the detailed study of the structure of translation algorithms and the development of methods which would permit such algorithms to be constructed as perfectly as possible. Moreover, attention is turned in MIAN to the development of a system of concepts which can be used to represent the grammar in a form convenient for the machine and required for the machine translation.

Both groups also work on automating the process of constructing translation programs.

Research on machine translation from English into Russian started in ITM i VT in the middle of 1954. Results of the first translations obtained by using the machine were published in 1956. At the present time, research is being carried out on the construction of machine translations from German, Japanese and Chinese into Russian.

Research on the construction of a machine translation from French into Russian started in MIAN in the Fall of 1954. The first experimental translations were obtained by Spring, 1956. At the present time, there is a theoretical study of the possibilities of machine translation on material of an experimental version of a translation from French and an experimental version of a translation from English into Russian has been completed. Both have been performed on the basis of the structural correspondences between the languages

Let us now describe the research carried out in MIAN. The first version of a translation from French into Russian was reserved for the translation of a mathematical text by using the machine.

Incidentally, this permitted us to be limited to a comparatively small dictionary. Also this results in a comparatively simple structure of the translatable texts. In the beginning, such a limitation on the problem was very important because it permitted a considerably earlier access to the construction of translation programs and to experimental translations.

The fundamental research on constructing rules for translating from French into Russian was conducted by O. S. Kulagina and I. A. Mel'chuk.

The first step was to work out a system of rules which, when used formally on a French text, would result in a Russian translation on this text.

Initially these rules were formulated on the basis of observations on the translation process. Correspondences were established between specific grammatical constructions of both languages. It soon became clear that the classification of words used in the grammar was not always convenient for use as the basis of a machine translation. This classification had to be made more precise. Thus, in place of verb or adverb as independent classes of words, transitive or intransitive verbs had to be used, conjunctions were split into coordinate and subordinate. The numerals and pronouns were regrouped and partially turned into substantives and adjectives.

Which grammatical information is sufficient for an exact formal translation from French into Russian gradually stood out. This information splits into three parts. The first part is information on the separate words of the sentence, including their permanent signs independent of the specific form of the word.

These signs are the grammatical bases of words which can be inserted directly into the dictionary. Included here are such signs as part of speech, types of formation of different forms of the word, capacity to combine with other words, etc.

The second part of the grammatical information refers to the form in which the given word enters in the sentence. It is determined by the word ending. Tables of endings are composed of all the altered parts of speech. Comparison of the ending of the word being analyzed with these tables provides information on its grammatical form.

Finally, the third part of the information refers to the structure of the sentence; it is drawn from an analysis of the mutual location of the words in the sentence by using a special algorithm which composes the analysis part of the translation rules. These rules verify the presence of any kind of special constructions in the sentence being translated and the conclusion is drawn that the translation should be realized by one or another Russian construction.

After all the required grammatical information on the structure of the Russian sentence has been obtained, the following problem arises—to construct the Russian sentence. To do this, it is necessary to extract the Russian equivalents of the French words from the dictionary, to arrange them in the required order, and to present them with the required grammatical form. This makes the second part of the rule—synthesis.

Let us present several examples of sentences translated by using the STRELA on the basis of the translation algorithm developed in MIAN.[2]

1. Admettons donc que l'intégrale ait un certain nombre de points singuliers logarithmiques. (Let us admit then that the integral has a certain number of logarithmic singular points.)

Dopustim znachit, chto (chtoby) integral imel nekotoroe chislo logarifmicheskikh osobykh tochek. (Let us admit then that the integral has a certain number of logarithmic singular points.)

2. Indiquons une autre méthode pour établir l'existence des intégrales des equations differentielles ordinaires. (Let us indicate another method to establish the existence of integrals of the ordinary differential equations.)

Ukazhem drugoi metod, chtoby ystanovit' sychchestvovanie integralov obyknovennykh differentsial'nykh uravneini. (Let us indicate another method in order to establish the existence of integrals of the ordinary differential equations.)

3. Or, si le nombre k augmente indéfiniment, on obtient $A = x^n + x^{n-1} + \ldots + 1$, c'est-à-dire que tous les coéfficients deviennent égaux à l'unite. (Thus, if the number k increases indefinitely, one obtains $A = x^n + x^{n-1} + \ldots + 1$, that is to say, that all the coefficients become equal to unity.)

Itak, esli chislo k vozrastaet neogranichenno, my polychaem $A = x^n + x^{n-1} + \ldots + 1$, t. e., chto (chtoby) vse koeffitsienty stanoviatsia ravnym edinitse. (Thus, if the number k grows without limit, we obtain $A = x^n + x^{n-1} + \ldots + 1$, i. e., that (in order that) all the coefficients become equal to unity.)

Programming a translation is of enormous and unique difficulty. On one hand, the difficulty is in the volume of the program. Thus the program to translate from French into Russian consists of 7000 instructions and 2000 auxiliary constants (including the grammatical tables). It decomposes into 17 separate programs operating in succession. All these programs operate once in sequence when each sentence is translated.

The compilation and separation of such programs is a complex and difficult matter. Specific difficulties are still caused by requirements imposed on the translation program to cut down the expenditure of machine time in experimental translations.

It appears to be expedient to code the grammatical information differently in different steps of the research. Special registers are set aside therefor in the dictionary and such methods are used for its coding as would cut down the number of registers expended for storage. This information is drawn from the dictionary along with the words. Furthermore, recoding of the information occurs.

Classes are isolated in which are combined the words having the same effect on the analysis and translation of the sentence. A special register is set aside for each such class and a scale of the given class of words is constructed therein. The places of the registers correspond to words of the sentence. If a certain word belongs to an appropriate class of words, then a one is placed in the place of this word otherwise, a zero. Hence, the scale of a certain class of words shows the distribution of words of a given class in the sentence.

Such a method of storing the working information permits a unique verification of which laws are suitable and it requires a small number of machine cycles for each individual check.

The experimental translations carried out have permitted a clarification of what is the frequency of utilization of any of the operations during execution of the translation program and of which requirements should be imposed on special translation machines at present.

The next step in the derivation of general methods of constructing translation algorithms was the development of a machine translation from English into Russian (T. N. Moloshnaia). This algorithm was worked out on the basis of principles which differ from the principles for French-Russian translation.

The role of the word in the English sentence is determined not so much by means of morphology as by means of syntax, i.e., by the order and grouping of the words in word-combinations or grammatical configurations. Consequently, the rules for machine translation from English into Russian are based not on a word-by-word analysis of the sentence but on its analysis according to the simplest syntax relations, i.e., according to elementary grammatical configurations.

The simplest grammatical configurations of the English and Russian languages have been separated out and a correspondence between them has been established. The translation is accomplished as follows: The English sentence is subjected to analysis, which consists of looking for the simplest grammatical configurations and then the Russian sentence is synthesized from the Russian configurations corresponding to the given English.

Homonyms, i.e., the formal coincidence of several words belonging to different parts of speech, are a definite difficulty in machine translation. Rules of distinction are formulated for each homonym case. Part of them is based on grammatical endings characteristic for specific parts of speech or classes of words. However, such rules appear to be inadequate. In this case an analysis of the surrounding words is required in order to resolve the question of whether a word belongs to one class or another.

G. P. Bagrinovskaia and T. L. Gabrilova have developed a program in MIAN to translate from English into Russian.

The grammatical information in these programs is also set to scale and the analysis of the configuration is made by using logical operations performed on these scales. As a result, special derived scales are obtained for the separate

[2] TRANSLATOR'S NOTE. The Russian is rendered in the Library of Congress translation scheme. Translations in parenthesis are not precisely literal.

configurations of the English text first, and then of its translated Russian text.

It should be granted that the structural direction in linguistics, which is very fruitful for machine linguistics, has not yet been developed here as an independent science.

For subsequent use of data on the structure of languages from the machine translation viewpoint, special research on linguistic statistics, particularly on the statistics of grammatical configurations, should be carried out.

The research carried out on developing translation algorithms and on programming them has led to the necessity for special theoretical investigations.

One of the problems is to construct a certain system of set-theoretical concepts, which can be used to construct the grammar of any language in a natural manner. At present, O. S. Kulagina has constructed a system suitable for the majority of European languages. Use of this system of concepts is convenient to the writing of rules for translation of one European language into another.

Another problem is to develop a special system of elementary operations from which it would be convenient to synthesize the program analyzing the translation algorithms.

O. S. Kulagina constructed such a system of operations on the basis of a consideration of the translation program from French.

These operations are adapted to check the logical conditions and also to recode and transfer the individual elements of information from one section of the memory to another. A special compiler program in which there are programs prepared for each of the operations mentioned can, by producing a program scheme described by using the operations named, rework it into the appropriate translation program. The fundamental part of the time-consuming labor involved in composing translation programs is thereby eliminated. Quite recently the range of research dealing with machine translation has broadened.

In the Language Institute AN USSR, I. A. Mel'chuk has developed an algorithm for the translation from Hungarian into Russian, which basically follows the path which had been developed for the translation from French. Furthermore, he has undertaken the development of principles for the construction of an algorithm to translate from any language into another within a certain group. This algorithm is the following: It is explained, at first, by which grammatical means is any relation between concepts, expressed by words, expressed in each of the languages. Furthermore, the relations between words in the translatable sentence are clarified by means of formal grammatical signs, then a word-by-word translation is obtained and, finally, the translated sentence, invested in the appropriate grammatical garb, is then composed on the basis of information on the structure of the translatable sentence. These researches are presently being conducted on the basis of Russian, French, English and Hungarian.

Research on semantics and cybernetics, being conducted in the Laboratoria Elektromodelirovaniia (LE, Electrical Simulation Laboratory) under the supervision of V. A. Uspenskii and V. V. Ivanov, is closely allied to machine translation.

In Leningrad, there is an all-city seminar on questions of machine translation where research has begun on the creation of translation algorithms for a number of foreign languages.

A seminar on questions of mathematical linguistics is also conducted in Kiev. The necessity is perceived of establishing closer contact between the various groups concerned with machine translation. This is because representatives of various specialties and different groups participate in this research. In this connection, a number of organizations (Mos. gor. ped. in-t inostrannykh iazikov, LE, Institut iazykoznaniia, MIAN) have formed an association on the problems of machine translation, which will discuss and publish work on machine translation.

A group of linguists under the supervision of V. A. Agaev work in Gor'kii on the construction of translation algorithms from English and French for radio physics. The basis for this research is a 200 word dictionary.

2. Utilization of Machines for Economic Purposes

Of great interest is the utilization of computers for various questions related to the control of the national economy. Among the problems here are: How to formulate the optimum plans for prescribed technical possibilities and prescribed requirements on the complexity of production; the formulation of rational transportation plans; finding expedient values for different kinds of production and also utilization of computers for the planning of technological processes and the automatic control of production. It must be noted that problems arise under the conditions of a planned socialist economy which differ from the economic problems which arise in a capitalist economy. This difference is based on the fact that, in capitalism, production is developed primarily in the interests of the enterpreneur while production, in socialism, is developed mainly from the interests of the socialist state and the nation. Abroad, many are concerned with questions of mathematical economics but these investigations are basically the concern of particular firms.

Here, research in mathematical economics and the utilization of computers for economic purposes, at a level of theoretical work of a mathematical nature, is being done by L. V. Kantorovich and his colleagues and the mathematical group of the machine control laboratory: A. L. Brudno, V. D. Belkin, A. G. Lunts and others, and in the Gor'kii Research Physical-Technical Institute (GIFTI) by A. M. Gil'man.

In the late 30's, L. V. Kantorovich proposed a method of constructing optimum plans. This method is that the economic problem reduces to the problem of finding a maximum linear form on a convex polyhedron in some multidimensional space. L. V. Kantorovich developed the method of the so-called steepest descent to solve such problems. At the present time, a number of different

methods has been proposed to find the extremums of linear functions on convex polyhedra.

Such problems are now called linear programming problems. (The term programming is here related to the fact that a rational plan of action is usually of interest here. It has no relation to 'programming' for computers.)

All these methods require the performance of tedious computational work in the important practical cases. Consequently, they require the use of computing machines.

The purpose of the research of A. L. Brudno and his co-workers is to construct an apparatus which will enable the determination of the outlay in productivity in the manufacture of a definite product, and rational costs as well. In the method the matrix of the 'interaction' of several branches of industry is studied. Each line corresponds to a definite producible product and each column to a definite product used in the manufacture. The quantity of the product to be expended which is necessary to manufacture a production unit and its preliminary cost are put on the intersection. A separate column is provided for labor. A column is provided for products sent to external markets. Iteration of such matrices enables the total expenditure of some products in the manufacture of others and rational costs to be found.

Similar methods have been developed by W. Leontieff in the U. S. A. in application to the economics of a capitalist society.

Quite recently A. G. Lunts disclosed that an economics professor in Moscow, Dmitriev, was occupied with an analysis of similar concepts in the 60's.

It seems that the Leontieff and Dmitriev results, although they are not in absolute agreement because of the difference in initial concepts, can easily be interchanged.

These researches are of great interest for the development of mathematical economics of a socialist economy. On the other hand, the development of research on the direct control of technological processes is very important. Here should be mentioned the work of A. M. Gil'man, who developed a method of planning technology for lathes by using computers.

3. Games and Machines

Playing intellectual games in machines is of value in assessing the possibilities of the machines and also in looking for general principles to raise the productivity of algorithms.

In realizing the game in the machine, the question arises of formalizing the tactics, of a rational performance of the tactical algorithm, and of coding the game information and the rules.

The following games have been played on machines in past years: V. M. Kurochkin constructed a program to solve two- and three-way chess problems by using the Besm. A. N. Krinitskii constructed a program for the game 'nim', IU. A. Pervin for the game of 'goat' in dominoes, N. I. Gus'kov and A. N. Liapunov (Leningrad) for certain variations of games with crosses and zeroes. These programs were constructed for the Strela.

All these programs to play games by machine operate completely successfully.

3. Theoretical Investigations of Control Systems

The question of synthesizing control systems has two aspects: the technical and the mathematical. The technical aspect is related to the construction of specific apparatus. The technical subject is generated by the mathematics. The research of our compatriots V. I. Shestakov, M. A. Gavrilov, and others played a great part in these questions as did the research of foreign scientists such as Shannon, von Neumann, Aiken, and others.

At the present time in the Soviet Union there are a number of collectives working out methods of synthesizing control apparatus. A considerable part of this work is primarily of engineering nature. However, only those works on the synthesis of control apparatus in which the mathematical aspect is predominant will be considered in the present survey.

Two tendencies can be noted in the development of control system theory. The first tendency is the study of methods to synthesize control apparatus composed of more and more diverse elements. Included here are relay-contact, electronic, ferrite, transistor, and other circuits. On the other hand, the problem arises of studying the construction of principles to synthesize control systems composed of elements of a completely definite but generally arbitrary nature, which is related in a natural way to the establishment of a general and precisely defined concept of a control system.

The second road of investigation leads to the solution of certain mathematical problems which arise from the theory of contact circuits but are of very great value and have not been accessible to solution because of the mathematical difficulties.

Substantial results have been obtained in the Soviet Union in the current decade in both these tendencies.

The process of extending the range of investigation occurs not only because of a simple extension of the set of objects to be studied but also because of the inclusion of already complicated domains (as, for example, the theory of graphs, disjunctive normal forms, etc.) into a single analysis. Hence there occurs a comparison of objects, a formulation of problems, and this often leads to the use of results from one domain in another and sometimes even to the transfer of theorems and methods.

Furthermore, since identical problems arise for different schematic objects, it seems to be possible to select 'a model object' which is less complicated by second order singularities which make solution of the problem difficult than are the others. Success in solving the problems depends to a considerable extent on the selection of the model object. For example, it appears that it is simpler to analyze oriented circuits (electronic type) than contact circuits (substantially nonoriented) in elucidating the

difficulties of circuit synthesis. Perhaps, an attempt to establish asymptotic regularities on the basis of contact circuits has generally retarded the search for asymptotic regularities for circuits.

A new branch of cybernetics, automata theory, with origins in the work of MacCullough and Pitts, Kleene, Burns, Wright, von Neumann, Moore, Culbertson etc., recently emerged and was rapidly developed.

In substance, this subject is the abstract consideration of computer operation taking the fact that its memory has a rigidly limited volume into account. Each automaton is a network with a definite input and output, where the input is subject to external influences. Time is considered discrete. Elements, called neurons, are placed at the network junctions. These elements are capable of reworking the information presented in a definite manner. Each such element can have many inputs and outputs. The signals circulating in the automaton can take on one of two values just as the elements of the nervous system, the neurons, can take on one of two possible states. Depending on the state in which the element is found, it does or does not deliver the impulse to the output. The element takes on one or the other state in the next instant depending on which impulses arrive.

The fundamental questions is what are these sets of external stimuli which the automaton can recognize and also there is the question of methods to synthesize automata.

S. Kleene solved the question of which external events can be represented by an automaton. Another solution of this question, simplifying and extending the results of Kleene, has been obtained by IU. T. Medvedev. L. A. Skorniakov used algebraic methods to study automata.

For example, let there be an apparatus (fig. 1) with n discrete input and m discrete output channels. It can be considered as an apparatus with one generalized input and output channel (fig. 2).

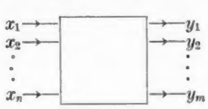

FIG. 1

FIG. 2

It is assumed that all the channels are in the final number of states, wherein the state β_n of the output at the instant t_{p+1} is determined completely by the states α_1, α_2, . . . , α_n of the input at the instants $t_1, \ldots, t_p$.

The apparatus (fig. 2) converts the sequence $\alpha = \alpha_1, \alpha_2, \ldots$ into the sequence $\beta = \beta_1, \beta_2, \ldots$. This transformation defines a certain operator T such that $T\alpha = \beta$.

The following problem arises: How does the nature of the operation T affect the simplicity of the circuit. B. A. Trakhtenbrot proposed a graphical method (the method of trees) to investigate such operations, and he found the characteristics of the operation T, called the weight and estimating its complexity. B. A. Trakhtenbrot established the properties of operators with prescribed weight, and it has been shown that the magnitude of the weight determines the number of delay elements, i.e., the volume of the internal memory of the automaton.

It is known that the selection of the language in which the conversion of the information is described (tables, graphs, functions of logic algebra, sequences of functions of logic algebra, matrices, etc.) affect the method of synthesizing the circuits, particularly for separate classes of functions. Consequently, the problem is posed of searching for new means to describe the circuit operation. By the way, it is sometimes required to construct canonic equations, according to this description, of the operation of the automaton determined by the relations

$$y(t) = \Phi(x(t), z(t-1)), \qquad z(t) = \Psi(x(t), z(t-1)),$$

where x, y and z are, respectively, the variables describing the input and output channels and the internal memory (fig. 3).

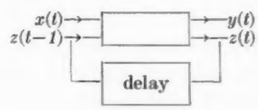

FIG. 3

M. L. Tsetlin introduced special matrices of Boolean variables to describe the operation of such circuits. In a number of cases these matrices permitted direct synthesis of the circuit. B. A. Trakhtenbrot proposed the use of extended predicate calculus to write the reworking of information, wherein predicate quantors, bounded subject variable quantors, and just single-place predicates would be allowed. There is a number of other works which give various approaches to the solution of the problem of synthesizing automata. Thus, M. L. Tsetlin considered the question of the composition and decomposition of automata into sub-automata on the basis of a special matrix calculus.

IU. IA. Bazilevskii proposed an interesting language to describe automata operation.

In addition to the works mentioned which are devoted to circuit synthesis independently of the physical nature of their constituent elements, significant results have been obtained in recent years in the synthesis of circuits with specific elements.

Thus, for example, the tabular (more accurately, graphical) method of synthesizing so-called multicycle relay circuits, proposed in the monograph of M. A. Gavrilov and then developed by V. N. Roginskii, V. G. Lazarev and others, has received wide circulation. In this method, the table (graph) of connections shows the sequence of states of the circuit inputs and outputs. Moreover, this table is extended to sequences of states of intermediate relays by using special receivers (satisfying the requirement of not

being contradictory). The circuit can be constructed according to the completely composed table.

V. I. Shestakov proposed a vector-algebraic method of synthesizing so-called autonomous relay circuits, which permitted him to formulate certain general statements. V. I. Shestakov generalized this method to nonautonomous circuits.

Methods of synthesizing electronic circuits by using multivalued logics were developed on the basis of investigations made by S. V. Iablonskii on k-valued logic from a function-theoretic viewpoint.

M. IA. Eingorin gave a method of constructing memory circuits with a given number of states by using a lesser number of tubes than is usual. Using the above mentioned matrix method of synthesizing circuits, M. L. Tsetlin proposed an algebraic apparatus to synthesize triggers. M. L. Tsetlin and L. M. Shekhtman worked out an algebraic apparatus to synthesize control apparatus from a single type of ferro-transistor cells.

In past years a considerable number of works has been devoted to searching for methods to construct contact circuits. Most well-known in this domain are the works of M. A. Gavrilov devoted to so-called bridge circuits. An effective general method of synthesizing contact circuits (the so-called method of cascades) was proposed and investigated in detail by G. N. Povarov.

A large part was played also by methods of taking so-called unused states into account, developed by V. N. Roginskii, who also proposed a corresponding algebraic apparatus (transformation of equivalences). The mathematics of the problems arising here was studied in detail by IU. I. Zhuravlev.

V. N. Grebenshchikov proposed a method to synthesize contact circuits which uses the equations of logic algebra.

In past years, matrix methods of investigating contact circuits, proposed by B. I. Aranovich and A. G. Lunts, received considerable development. The matrix elements introduced in these methods are the conductivities between the poles of a contact multiterminal network. Furthermore, A. G. Lunts developed a complete algebraic apparatus which would permit various transformations to be made on circuits of very general form, circuits to be simplified, etc. The methods of A. G. Lunts received further development in the work of G. N. Povarov and in a number of foreign works. In passing, let us note that matrix methods were used by G. N. Povarov to solve a number of interesting problems of logic.

M. L. Tsetlin proposed another matrix method of synthesizing contact circuits. The substance of this method is that the input and output busbars are separated in the circuit and rectangular matrices are constructed whose elements are the conductivities between the input and output busbars. The method is especially effective in synthesizing circuits consisting of individual blocks.

A. SH. Blokh carried out a further significant development of this method, which, in its general features, reduces to the introduction of an intermediate integer parameter for the matrix functions.

A. V. Kuznetsov and B. A. Trakhtenbrot developed topological methods of the theory of contact circuits. A. V. Kuznetsov proved that no analog of the reciprocity principle exists for nonplanar circuits. He also found conditions for the indivisibility of non-iterated contact circuits (i.e., circuits having just one contact for each relay). B. A. Trakhtenbrot obtained conditions for the possibility of realizing functions of a noniterated circuit, and he developed methods of synthesizing such circuits and also showed, substantially, the uniqueness of such a realization.

A number of works has been devoted to the synthesis of circuits which realize separate classes of functions of logic algebra. Let us note here the research of G. N. Povarov, V. K. Korobkov, B. I. Finikov and others. A. D. Kharkevich studied the interesting class, important in applications, of so-called commutation circuits.

An important circle of problems, which result from the theory of contact circuits, includes the construction of general methods of synthesizing circuits with bridges. These problems reduce to the study of the general properties of sets of functions of logic algebra and other objects. These problems are a continuation of the classical research of C. Shannon and they have received considerable development in very recent years. Let us dwell on these questions in rather more detail.

In order to estimate the complexity of synthesizing circuits, Shannon introduced the function $L(n)$ which represents the least integer, for each n, such that each function dependent on n arguments can be realized by a circuit with a number of elements not exceeding $L(n)$.

Evidently, many methods of synthesis afford the possibility of estimating $L(n)$ and we estimate the power of these methods by the divergence between the upper and lower bounds of $L(n)$.

In 1949, Shannon showed that

$$(1-\epsilon)\,\frac{2^n}{n} < L(n) < (1+\epsilon)\,\frac{2^{n+2}}{n}\,.$$

These estimates differ by four times, and the question remained open relative to the behavior of $L(n)$ for large n. Many attempts were made to solve this question. G. N. Povarov, perfecting the Shannon method, obtained an effective synthesis method (the so-called method of cascades). However, from the asymptotic viewpoint, the G. N. Povarov method added nothing new. Quite recently, O. B. Lupanov succeeded in showing that $L(n) \sim 2^n/n$. The Shannon problem was thereby solved. This last solution was achieved by constructing a new method of synthesis using fine considerations relative to the structure of functions of logic algebra. As an intermediate result, O. B. Lupanov gave the construction of a multiterminal network, realizing all the constituents of unity in the variables $x_1, x_2, \cdots, x_n$ which contains, asymptotically, half the number of contacts than in the tree.

O. B. Lupanov also studied methods of synthesizing (with estimates) circuits of so-called functional elements, contactor-gates, series-parallel circuits, and certain others for which asymptotic expressions were successfully obtained in a number of cases.

R. E. Krichevskii considered formulas which are the superpositions of certain basic functions. He obtained a result which when applied to k-valued logic sounds thus: Almost all functions of k-valued logic $f(x_1, \cdots, x_n)$ require not less than $C \cdot k^n/\log n$ letters to be described asymptotically by means of basis functions (generalization of Riordan-Shannon theorem).

The preceding results show that the overwhelming part of the functions requires, for their schematic realization, on the order of $2^n/n$ elements (contacts, contacts and gates, etc.), i.e., has the most complex circuits. In substance, they indicate that it is not expedient to pose the question of working out unique methods of synthesis for all functions.

In addition to these questions, it is of great interest to try to prove the minimality of any kind of circuit. This problem is very difficult.

K. Kardo established the minimality of circuits realizing linear functions.

A. A. Markov obtained a method to synthesize minimum contactor-gate circuits for monotonic symmetric functions. This method permits minimum circuits to be constructed with a number of contacts equal to the square of the number of variables in order of magnitude (methods known up to now have only permitted the construction of specific circuits with a linearly increasing number of contacts).

A. A. Markov also investigated the interesting question of the inversion complexity of functions of Boolean algebra.

IU. L. Vasil'ev made an analysis of a large number of circuits in order to discover sufficient conditions for minimality. He compiled a catalog for circuits realizing functions of four variables. The catalogs of G. N. Povarov and of Higonnet and Grea are the basis for that of Vasil'ev.

It is impossible not to mention here the numerous works devoted to the creation of machines for the automatic synthesis of circuits performed by T. T. Chukanov, V. N. Rodin, P. P. Parkhomenko, A. A. Arkhangel'skaia, V. G. Lazarev, V. N. Roginskii, and others.

An interesting problem related to circuit theory was considered by S. V. Iablonskii and I. A. Chegis, who created a general theory for the construction of tests to detect malfunctions in circuits when these malfunctions are systematic (not random) and "ringing through" the circuit is the only way to detect the malfunctions, i.e., to analyze circuit operation under definite external conditions.

Here, it would appear that a direct interrelation exists between the construction of the tests and the construction of the so-called blind-alley disjunctive normal forms.

Let us recall the work of IU. I. Zhuravlev in which the question is considered of the selection from tables. Operations admissible for samples consist in the verifications of definite tabular elements. IU. I. Zhuravlev solved the problem of constructing algorithms to solve sampling problems by using the asymptotically minimum number of acts.

Very important results related to circuit theory and due to S. V. Iablonskii will be described in the next section.

4. Certain Other Problems of Mathematical Cybernetics

Important results, obtained most recently and related to a number of mathematical problems occurring in cybernetics, will be briefly explained in this paragraph.

Certain circumstances of a set-theoretical nature unexpectedly appear in questions concerning the synthesis of contact circuits.

It is often necessary to differentiate constructions, effective in some sense, and constructions, relying on the axiom of arbitrary choice (Zermelo's axiom), in set theory. As a rule, the constructions in the latter case contain a set of elementary acts of considerably higher power. The synthesis of a minimum contact circuit which realizes a prescribed function of logic algebra can always be performed in a finite number of steps. However, in the general case this requires the sorting of all possibilities within definite limits, i.e., in order to synthesize the minimum circuit; then for a definite function it is substantially necessary to examine all circuits which can be constructed from the required number of elements.

The question naturally arises of how to proceed so that an almost minimum synthesis would be performed by substantially the least number of elementary acts. This approach has much in common with the so-called effective approach in set theory.

S. V. Iablonskii obtained important results on this question quite recently. He analyzed the question of the structure of such classes of functions for which it is expedient to create a special algorithm to synthesize the circuits which realize them.

Classes of functions of logic algebra, called invariant, are introduced. The characteristics of these classes are that they are invariant relative to remaining of the variables and substitution of constants as well as relative to the attribution of unessential variables.

Let Q be a certain class of the type described. Let us denote the number of functions dependent on the variables $x_1, \cdots, x_n$ and entering into Q by $P_Q(n)$.

Let us consider the expression $[P_Q(n)]^{1/2^n}$. It appears that it just decreases as n increases. Let us put

$$\lim_{n \to \infty} \sqrt[2^n]{P_Q(n)} = 2^\sigma$$

where $0 \leqq \sigma \leqq 1$. Let $L_Q(n)$ be the number of contacts which can be used to realize any function of the class Q that depends on not more than n variables. Then if $\sigma > 0$, there is a method of synthesis for which

$$\lim_{n \to \infty} \frac{L_Q(n)}{L(n)} = \sigma .$$

Let us note that there is a continuum of mutually differing

classes satisfying the conditions of S. V. Iablonskii, for $\sigma \neq 1$. Only the class of all functions of logic algebra satisfy these conditions for $\sigma = 1$.

The method of synthesizing functions in a certain class Q requires substantially less sorting of the possibilities than does the method of synthesis suitable for all functions of logic algebra.

Another question considered by S. V. Iablonskii in the same work is the following: Let there be given a certain sequence of functions of logic algebra. It is required that it be possible to indicate the least invariant class which contains this sequence. It appears that, if such a sequence is evolved by random sampling so that any function of the variables $x_1, \cdots, x_n$ can be selected at the nth step with the same probabilities, then the aforementioned invariant class agrees, with probability 1, with all the functions of logic algebra. However, in order to establish that a certain individual sequence of functions generates the class of all functions of logic algebra is the sense indicated, a complete sorting of all the possibilities is again required. Such a picture is here obtained that the Zermelo approach can be replaced, with probability 1, by the Monte-Carlo method. However, the exclusion of the 'adverse' event of zero probability again requires a complete sorting of all the possibilities.

The S. V. Iablonskii work described is of great interest from the viewpoint of tracing the role of the general principles of set theory in mathematical questions of cybernetics. Clearly posed in this work is the question of the interrelation between the objective difficulties contained in the problem to be solved and in the complexity of the algorithm by which the given problem is solved.

A rather different approach to the problem of algorithms with estimates was made by A. G. Vitushkin. He started from the study of multidimensional variations of functions of many variables and the mapping of functions of many variables with a given degree of smoothness by using the superposition of functions of the least number of variables of given smoothness. A N. Kolmogorov disclosed that these problems reduce to the analysis of information which is contained in an ϵ-approximation of an arbitrary function of a given class.

In this connection, A. G. Vitushkin formulated the problem of how to estimate the difficulty of calculating an arbitrary function of a given class if the quantity of information that must be prescribed to obtain the ϵ-approximation to any function of this class is known.

The difficulty of the problem of calculating individual functions consists of two elements. Let there be a class of algorithms which permits any of the functions being studied to be calculated. These algorithms are characterized by a certain common structure and differ in the numerical value of certain parameters. In order to determine the individual function, it is necessary to prescribe the value of these parameters. Moreover, a specific quantity of events must occur according to the selected algorithm in order to calculate the value of the functions for prescribed values of the arguments.

Hence, we have two parameters to assess the 'quality' of an algorithm: p, the number of parameters on which the individual algorithm depends, and k, the number of operations to be performed by this algorithm.

A. G. Vitushkin established that if the smoothness of a class of functions is defined by their differential properties and the number of arguments on which they depend, then, if the ϵ-entropy of a certain class of functions is denoted by H_ϵ, the inequality

$$p \log (k + 1) \geqq H_\epsilon$$

holds for every class of algorithms which affords the possibility of calculating any of these functions with ϵ-accuracy.

The quantity H_ϵ can be determined for many classes of functions according to formulas given by A. G. Vitushkin in an earlier work:

$$H_\epsilon = C \cdot \epsilon^{-n/(q+\alpha)}$$

if the class of all functions of n variables is considered, where the functions allow q derivatives with respect to all the variables wherein the last derivatives satisfy the Hölder condition with exponent α. The research of A. G. Vitushkin on studying tabulation algorithms, which is described here very incompletely, is distinguished by the depth of the results and the power of the function-theoretic construction. Exactly as does the work of S. V. Iablonskii, these researches refer to the general problem of calculating relations between the internal structure of objects and methods of forming them. In this case they reflect an intermediate link between function theory and cybernetics.

The works described are the first steps in the domain of the mathematical problems of cybernetics. They united some common directivities of projects which can be characterized as the beginning of the development of a general metric theory of algorithms or a theory of algorithms with estimates. However, the construction of such a theory is a matter of the future. This region is closely allied to mathematical logic and theory of algorithms and also to the general ideas of theory of sets and theory of functions of a real variable. The formulation of problems of this domain is closely related to many questions beyond mathematical domains. On the one hand, this is control engineering and on the other, the biological sciences, primarily physiology, genetics and evolutionary biology and, finally, economics. The development of this region is of great value to the broadening of the spheres of application of mathematical ideas to very diverse areas of human activity. This broadening of the spheres of application of mathematics is one of the most characteristic general phenomena of science in the middle of the twentieth century.

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Programming

M. R. Shura-Bura, *Mathematika v SSSR za Sorok Let, 1917–1957* (Forty Years of Mathematics in the Soviet Union), Moscow, 1959, pp. 879–886.

(Translated by Morris D. Friedman, West Newton, Mass.*)

The numerical solution of any problem is the determination of the values of a certain set of functions of a finite number of variables, the initial data of the problem. Here it is understood that a certain final algorithm is determined which permits the values of the desired functions to be obtained according to prescribed values of the arguments.

In order to solve the problem by using some kind of computing means, it is in the long run necessary to formulate this algorithm in terms of operations which can be performed by the means selected. In substance, such a description is a program of the calculation.

The need to formulate a program for calculations arose long before the appearance of the so-called machines with program control. However, very substantial difficulties emerged in the problem of program formulation only with the appearance of such machines, and the problem as a whole appeared to merit special investigations and the development of methods for its most logical solution. It is very remarkable that the reasons for the difficulties which arise are not by any means inadequacies of modern universal digital machines but rather their enormous possibilities.

Any algorithm can be described in terms of elementary operations of a universal machine. Any such description is formally a program for the solution of the appropriate problems. If this program were to be applicable, then the problem of programming for automatic digital machines would reduce to the translation of the prescribed algorithm into the language of the elementary machine operations. Even such a translation requires a certain extension of the given algorithm. Since it is here necessary to take into account the distribution and volume of the memory for the numbers and commands, the impossibility of performing operations in a number of cases without depositing intermediate results in certain cells of the memory prevents the inscription of a new result in the location of a quantity required later, and so forth. This extension of the initial algorithm could be formalized without particular labor, thereby reducing all the difficulties to the execution of purely technical work.

However, the "transfer" method mentioned seems, in substance, to be unsuitable. The fact is that in order to realize any algorithm with the aid of a machine it is necessary to insert all the initial information into the memory. Information on the algorithm of the solution, i.e., the program, is conceptually initial information for automatic digital computers. Consequently, the time required to realize the algorithm is known to be larger than the time expended in the insertion of the program. In the case where all the elementary operations which must be performed to realize the algorithm are inscribed as commands in the program inserted in the machine prior to solution of the problem, the rate of executing one elementary operation in the solution of the problem is limited by the rate of insertion of one command. For machines in which the time to complete a command is many times less than the time to insert this command in the machine storage, such a program is inapplicable.

In this connection, programs must actually be realized in terms of the elementary machine operations of a more general algorithm which will realize, in addition to the prescribed calculation algorithm, certain auxiliary operations which would guarantee the generation of commands within the machine for the execution of the prescribed algorithm.

The research of Soviet mathematicians on programming problems was started on the initiative of M. A. Lavrent'ev in the Institut tochnoi mekhanika i vychislitel'noi tekhniki Akademii nauk Soiuza SSR (ITM iVT AN SSSR—Institute of Precision Mechanics and Computer Technique, Academy of Sciences USSR), where the research whose results appeared in the monograph of a group of authors, "Solution of Mathematical Problems on Automatic Digital Computers" (L. A. Liusternik [71],[1] A. A. Abramov [7], V. I. Shestakov [5], M. R. Shura-Bura [7]) was carried out under the supervision of L. A. Liusternik in 1950.

The research during this period was made difficult by the lack of practical applications. It was reduced, basically,

* This translation was prepared for the Electronics Research Directorate, Air Force Cambridge Research Center, Air Research and Development Command, United States Air Force, Bedford, Massachusetts.

[1] Complete bibliography for this paper and for the paper by Liapunov in the previous issue will be published as soon as volume 2 of the series becomes available.—*Editor*

to comprehending the actual possibilities of the machine and to the investigation of various programming methods.

The introduction of electronic computers into practice gave a powerful impetus to the developments in this area. When the new machines were first unveiled, the problem was set of compiling programs to realize comparatively simple algorithms. The compilation of each such program was considered as the solution of an individual problem. The authors of programs sought the most economical solutions by using clever methods making unexpected use of some of the peculiarities of the machines. Various competitions arose on making improvements in some of the programs. In passing to the solution of more complex problems, there rapidly appeared the impossibility of solving programming problems in a similar manner. The growing volume of programs and calculations reduced the value of each clever solution of a particular question and, at the same time, made finding these solutions difficult. Under these conditions, simplicity appeared to be a more valuable property of programs in the sense of uniformity of the programming methods used, i.e., the methods of extending the initial algorithm, if not in the sense of space. During this period the basic concepts and treatment of programming methods were crystallized. Special research was conducted in the Mathematics Institute (MIAN) and in the Institute of Precision Mechanics and Computer Techniques (ITM i VT) on the basis of two high-speed computers.

In the attempt to solve complex problems, great difficulties appeared in the creation of programs without the preliminary compilation of so-called program schemes, or some kind of description of the algorithm in terms of sufficiently coarse operations.

The problem of programming decomposed clearly enough into two steps, of which the first is the selection of the extended algorithm and its description in terms of sufficiently large-scale operations, i.e., the compilation of a program scheme, and the second is the depiction of the selected extended algorithm in terms of elementary machine operations, i.e., by using commands.

One of the reasons for the difficulties which arise in programming is that complex algorithms must be described in terms of comparatively simple operations from a set of elementary machine operations. This fact leads to the necessity of dealing with a large number of commands and of taking into account, from time to time, all the sufficiently complex relations and interrelations between the commands while compiling the program. It is perfectly evident that it would be easier to program if there were more complex operations, as for example the operations of calculating the values of any elementary functions or operations on vectors and matrices, particularly operations solving systems of linear equations and even more complex operations, included in the set of elementary machine operations. However, the possibilities of extending the composition of the operations by means of the apparatus are very limited, if not indeed exhausted. At the same time, there exists the possibility of extending the set of operations by the creation of so-called standard subprograms which would realize any algorithm used with sufficient frequency. In composing a new standard subprogram, it must certainly be represented by using the existing set of operations which include, in addition to the elementary machine operations, even more complex operations realizable by using the subprograms already compiled. However, an operation which a new subprogram realizes can later be considered as an elementary operation.

One of the most essential problems which arises in the compiling of a standard subprogram is the problem of selecting an economical algorithm. The enormous operating speed of electronic machines, in comparison with hand rates, seems to make emphasis on the choice of economical algorithms for any kind of calculations superfluous, at first glance. However, the necessity to solve all the more complex problems very rapidly presents the programmer with the question of a means to accelerate the calculation, i.e., the problem of looking for more economical algorithms.

In particular, in solving an overwhelming majority of problems there is required multiple calculations of the values of elementary functions with an appropriate degree of accuracy. Even a superficial analysis of the role of these calculations in the solution of a number of problems would indicate the possibility of a substantial saving in the total time of solution under conditions to cut down somewhat on the time used to calculate the individual values of the elementary functions, primarily in the calculation of square roots, of exponentials, logarithms and trigonometric functions.

Of the large number of works in this area, the work by V. S. Shtarkman, perfecting a number of standard programs for the STRELA, the work of E. A. Volkov, which proposed new clever methods to calculate certain functions and which compiled a number of standard subprograms for the BESM which filled the permanent storage of the machine, should certainly be mentioned. A group from the Computation Center of Moscow University has recently achieved notable success in this area by substantially perfecting permanent subprograms for the calculation of elementary functions on the STRELA.

Individual, somewhat specialized units for subprogram storage are provided in the composition of certain universal computers. These units substantially facilitate the use of a small library of standard subprograms with the result that the problem of developing a rational system for using the standard subprograms, at least during the first hours of machine exploitation, is not as pressing as in the utilization of a machine without such specialized units. Consequently, it is not just by chance that research in the area of creating systems of standard programs was initiated in Moscow University by N. P. Trifonov, E. A. Zhogolev, G. S. Rosliako, and others in connection with the mathematical utilization of the M-2 machine. The system created for the M-2 was later the basis for creating a library of standard subprograms for the STRELA in the Computation Center of Moscow University. It is interesting to note,

in connection with the M-2, that in 1955–6 E. A. Zhogolev performed investigations, which merit attention, on the peculiarities of programming on fixed point machines which show that the very widespread opinion on the extreme difficulty involved in the mathematical utilization of such machines is highly exaggerated. The floating scale method proposed by S. L. Sobolev and developed by E. A. Zhogolev leads neither to a noticeable complication of the program nor to an increase in the time to solve the problem in comparison with its being solved on a floating point machine. A library of standard subprograms for the M-2 was compiled of two parts for both the fixed and floating point regions.

In addition to the standard subprograms which realize any kind of calculational algorithm, the so-called service programs intended to make any of the processes of solving the problem automatic play an essential role in the utilization of computers. Programs guaranteeing a check on the correctness of machine operation during the solution of the problem occupy an important place among such programs. Thus, for example, the standard program, created in 1954 in the Mathematics Institute AN USSR to check the exchange of information between various memory units of the STRELA-I, permitted the productivity of the machine to be raised by diminishing the number of errors in the programs and by the possibility of opportunely detecting machine errors literally several times. Later, similar problems were formulated for all STRELA and BESM machines. The program for automatic repetition of checking in order to check machine operation, which was compiled in the Computational Center of Moscow University, should be mentioned.

Using standard subprograms substantially saves programming time by significantly consolidating the elementary acts into which the algorithm to solve the problem must be divided. However, the use of each standard subprogram in a specific problem requires a certain transformation of the subroutine related to the distribution of the storage and the presence of other subroutines in the program of the problem. This transformation can be made automatic to a considerable extent, i.e., it can be entrusted to the machine.

The programs which are used to perform the required transformations, i.e., to compose the program as a whole out of separate subroutines, are called compiler or partial routines. In this connection, the routine appropriating the internal addresses and the standard partial routine (SPR) for the STRELA should be noted; it was created by E. A. Zhogolev in the Moscow University Computer Center in 1957. Also worthy of note is the "programming system of compiler type" developed in 1957 by a group under the guidance of IU. I. Morozov. The program of automatic appropriation of addresses (AAA), created in 1956 by E. Z. Liubimskii and T. Isaenko, is similar in idea to the SPR but it has greater universality. Another means of using the standard subroutine idea is the so-called interpreting method of programming, wherein the standard subroutines required to realize the algorithm are generated in the machine storage each time the demand arises.

In contrast to the compiler method considered above, the problem of storage distribution is simplified substantially in the interpreting method since the subroutines need not be conserved in the machine storage at the same time. L. V. Kantorovich, L. T. Petrova, V. A. Bulavskii, and others in the Leningrad section of the Mathematics Institute have been occupied with the development of various interpretive routines, which the authors call "prorab," since 1955. An experimental check of operations with prorabs showed that the interpretive method, in its pure form, is hardly widely applicable because of the many-fold rise in the machine time required to solve the problems. Consequently, later modernization of the prorabs proceeded, basically, along the lines of their being included in the system of the compiler method. An important peculiarity of the programming system developed by L. V. Kantorovich and others is the multidimensionality of the quantities with which the "prorab" can work.

Methods of using standard subroutines would not be so much perfected if they all assumed the very data of the subroutine, i.e., the parts, in advance.

Consequently, the standard subroutine method in itself cannot lead to complete automation of the second stage in programming, the description of the extended algorithm in terms of elementary machine operations.

Required for such an automation is first the formalization of the process of transforming from the scheme to the program. The problem was made complicated by the fact that only such methods as would lead to, so to speak, "good programs," i.e., to programs which do not have to be compiled manually, can be acknowledged as a satisfactory transformation. Moreover, an absolute requirement is simplicity of the initial information in comparison to that obtained as a result of the selected process of the program. The first attempts to compile programs by using machines were again inadequate since the information given by the machine differed very slightly from the usual program not only in substance but also in form. In this connection, the process of compiling the initial information for the programming was no easier than compiling the program itself.

The first serious advance in the direction of automating the second stage in programming is related to the creation of the "compiler program" CP-1 by E. Z. Liubimskii and S. S. Kamynin in 1954. The authors of the CP-1 set themselves the problem of formalizing and automating the transformation from the so-called operator scheme to the program. A. A. Liapunov proposed the method of writing the program by using an operator scheme in 1953. This method seemed to be considerably more convenient than the previously used method of the so-called block diagrams, in the majority of cases, and it gained in popularity at once. Initially, however, this method was only a convenient means to write the program or a sketchy plan for its compilation. Later, a more precise concept of an

operator and the clear discrimination of those basic types of operations, whose use can guarantee the compilation of good programs for the overwhelming majority of problems, permitted operator schemes to be used as the basic means of automating programming or, more accurately, automating its second stage.

The operator scheme, whose transformation to the program was performed by the CP-1, consisted of three kinds of operations; namely, logical operations P, re-address operations F and the so-called nonstandard operations H. A new, fortunate concept of parameters and of the dependences of the quantities on the parameters which the authors introduced contributed to the success of the CP-1, as did also the apparatus of conditional numbers which they proposed. A defect of the CP-1 was the fact that the initial information for the nonstandard operations was substantially material similar to the corresponding parts of the prepared program.

The CP-1 was a kind of model against which new ideas, the basis for the creation of the considerably more perfect compiler program CP-2 at the start of 1955, could be checked. This compiler program was designed by constructing the program according to the operations scheme in which could be found, in addition to the operations P, F, and H, the arithmetic operation A, the regeneration operation O and the dispatching operation Z. Algorithms which wrote formulas by using commands as well as algorithms of economic operation and of the working locations were realized in the CP-2. Related to the operation on the CP-2 is the formulation of the problem of economy of the re-address command, which is solved by using an algorithm realized with approximately the greatest economy.

Work on creating the CP-2 required the efforts of a large group of programmers. Participants in this research, under the supervision of M. R. Shura-Bura, were E. Z. Liubimskii, S. S. Kamynin, V. S. Shtarkman, E. S. Lukhovitskaia, I. B. Zadykhailo, and others. The essential peculiarity of the CP-2 is the block principle used to construct it, which permitted new parts capable of treating the information when we desire to prescribe it in a new form to be scanned without altering the program. Under this principle the information can also be referred to operations of new kinds. As a result of such a construction, differentiator blocks and new, significantly improved blocks to appropriate the real addresses, described by T. A. Trosman, were later attached to the CP-2. At the present time, research is proceeding on creating a sub-scheme block.

The compilation of a program with the aid of the machine was the first serious use of the machine for "nonarithmetic" purposes. Research on automating the programming afforded the possibility of realizing the machine possibilities anew and served as an impetus not only to the formulation and solution of problems on other nonarithmetic uses of the machines but also exerted some influence on the nature of the computer programs which appear to be, more and more often, to a considerable degree nonarithmetic. It is understandable that this afforded the possibility of solving considerably more complicated mathematical problems on the machines.

The success of the CP-2 served as a stimulus to the creation of similar programs on other high-speed machines. Thus, in 1955 V. A. Fedoseev composed a compiler program for the STRELA-II, and in 1956 A. P. Ershov compiled a routine for the BESM, and N. A. Krinitskii a routine for the STRELA in 1957. It should be noted that the authors of the new programs did not copy the CP-2 blindly, but they improved the program, found new interesting algorithms which would realize any step in the command schedule, and also introduced new kinds of operations. An interesting peculiarity of the A. P. Ershov program is the presence of the cycle, in the system he used, as a separate operation.

Speaking of the prospects for the further automation of the second step in programming, the new compiler program developed in the Computation Center of Moscow University, which is intended for use jointly with the standard subroutine method, should be mentioned. There is a basis to consider that most complete automation of the programming stage under consideration will thus be accomplished successfully.

Automation of the first stage in programming, i.e., the selection of an expanded algorithm and its description in terms of operations of a prescribed kind, rests upon the problem of formalizing the transfer from the initial to the expanded algorithm. Attempts at a formal description of programs, made by IU. I. Ianov (1955–1956), R. I. Podlovchenko (1956–1957), and A. P. Ershov (1956–1957), have not yet led to any substantial shifts in the direction desired. The successful solution of this problem is of considerable interest and could assist in solving the problem of automating the first step in programming.

The next step in programming is work on establishing the correctness of the program formulated, the so-called "debugging," which usually reduces to the detection and elimination of errors in the program. The process of debugging complex programs is very time-consuming and can consume considerable machine time in the absence of auxiliary means. Automation of this process is very desirable. Most complete automation can be achieved by using so-called checking routines. Underlying such routines is the idea of routine simulation of the machine control unit and the concept of various checking operations. The research of E. Z. Liubimskii, S. S. Kamynin, and T. A. Trosman should be mentioned in this connection.

The quite complete program of T. A. Trosman, composed for the STRELA-I, served as the basis for the creation of similar programs on other machines. The accumulation of experience on the mathematical use of universal digital computers occurred during operation with specific machines. Consequently, there is no doubt that the peculiarities of existing machines exerted a definite influence on the development of programming methods. However, the very rapid beginning became subject to the reverse effect of the development of programming methods on the moderniza-

tion of existing and on the choice of the construction of new mathematical machines.

In selecting a new construction it is very important to estimate exactly the role and the value of any of the machine parameters and its peculiarities as well. However, the experience of mathematical utilization only affords a qualitative picture of the influence of any of the parameters and the peculiarities on the machine productivity. Consequently, a statistical analysis of the operation of the various units of the machine in the region where the problem will be solved is of great value.

Interesting investigations of such a kind were made in 1956–57 by E. Z. Liubimskii and T. P. Kuznetsova, who obtained copious statistical data which are valuable materials in resolving the question of a rational choice of machine parameters.

In concluding this survey it should be noted that by far not all the research on programming has been mentioned herein which has been performed in the Soviet Union in the past seven years. Basically, only those have been mentioned herein which, in the author's opinion, proved to be definite steps in the right direction.

In estimating the results of research in programming, let us note the outstanding achievements, particularly in automation. Let us note a serious defect, namely, the inadequate quantity of publications explaining the results of the investigations performed and the brief reports of research in progress. At the present time, measures are being taken to overcome this fault; it is to be hoped that a systematic exchange of information by means of regular publications will shortly occur.